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ROSE AND CARLESS'

MANUAL OF SURGERY

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MANUAL OF SURGERY

For Students cit..ners

BY

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CONSULTING SURGEON, MAUDSLEY AND HAMMERSMITH HOSPITALS.
EXAMINER IN SURGERY TO THE UNIVERSITY OF LONDON; AND TO THE GENERAL NURSING COUNCIL FOR ENGLAND AND WALES, ETC

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EXAMINER IN SURGERY TO THE UNIVERS CAMBRIDGE.

THIRTEENTH EDITION

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FOREWORD

It is with very mixed feelings that I sit down to write a Foreword to this the thirteenth edition of "Rose and Carless," which for me is in reality a valedictory message. I am proud and happy to have been permitted to send out twelve editions during the past thirty-two years, and throughout this long period the book has retained its popularity, and has, I trust, fulfilled the purpose with which it was originally conceived—viz., to serve as a textbook for students preparing for their examinations, and also to be of use to practitioners when face to face with surgical problems in after-life. The constantly recurring testimony of those whom I have met in all parts of the English-speaking world makes me realize with much gratitude that this effort has not been in vain. The work was necessitated by the revolutionary changes that followed the teaching and practice of Lister, and made existing surgical textbooks of little use. The material was really an elaboration of notes which I had employed in tutorial classes for the Final Fellowship examination; this was worked over carefully with my late colleague, Mr. William Rose, and when the time appeared favourable was put into print. The resulting book was received with gratifying favour, and fresh editions were soon required. The burden of preparing these fell almost entirely on my shoulders, and ever since the retirement of my colleague I have been solely responsible for them, with the assistance of friends to whom I have been indebted for advice on special sections, and without whose splendid help I could never have carried on. They are altogether too numerous to mention, but to one and all of those who survive I would offer my very true thanks.

The preparation of illustrations constitutes no small part of the work of author or editor, and to friends who have helped by providing these, and to the artists who have worked upon them, the book is much indebted.

Behind all these collaborators and occupying a place of helpfulness second to none, I would express thanks to the publishers, and especially to Mr. A. A. Tindall, jun., who has always been ready with valuable suggestions, useful encouragement, and tactful advice, and has not stinted the provision of illustrations or other costly means for improving the book and furthering its interests.

Thus it has progressed for thirty years, with constant changes necessitated by the rapid advances of one of the most progressive sciences. There was a time when surgery was looked upon as

"merely common sense with a little technical knowledge," as one of my old teachers used to say, but during my lifetime it has been transformed, and is now a beneficent and beautiful art based on sound scientific principles.

The time has at length come when by lapse of years I must lay down the editorial pen and pass over the work to younger hands and brains. I am happy in having one of my old pupils and house surgeons in the place of editor-in-chief, and I feel confident that Mr. Cecil P. G. Wakeley, who has already helped me in two editions, will not only maintain the work on the old lines and carry on the old traditions (in so far as they are good and true), but will also bring to it the energy and freshness which are only too likely to be missing when the direction is retained too long by one person. He has already suggested improvements which have been brought into effect, and will, I believe, add to the usefulness and value of the book, and he has gathered round him a band of fresh workers whose contributions will be most valuable. Amongst them I greet most heartily his colleague on the surgical staff at King's College Hospital, Mr. John B. Hunter, whose name and ancestry are a sufficient recommendation. The co-operation of these helpers ensures that what is here sent forth is up-to-date, and thus I am able to hope with confidence that the future success of the book will not be less than that which it has secured hitherto. The old title will be retained, and I am glad to think that my name and that of my colleague, Rose, will still be remembered. The work has been my main contribution to the profession which I have loved so truly and striven to serve faithfully. From my Scottish home I shall watch its progress with affectionate interest.

ALBERT CARLESS.

OVERDALE,
CRIEFF,
PERTHSHIRE.
August, 1930

PREFACE

Three years only have elapsed since the last edition of this book was published, and yet surgery has made many advances during this comparatively short time. When my late chief, Mr. Albert Carless, decided to take no active part in the production of the present edition, it came as a great blow, for his stimulating enthusiasm, his wealth of surgical knowledge, and his ever-ready help were invaluable in the preparation of former editions with which I was associated. I have, however, been most fortunate in having his help in reading the proofs, and in giving us many valuable suggestions which have proved more than useful.

The name of Carless will be remembered for many years to come, as his textbook, which first appeared in 1898, has already gone through twelve editions, and has been translated into many languages, including Chinese and Arabic. In the Preface of the last edition the work of Lister and its bearing on the surgery of to-day was alluded to. One cannot help but feel that Lister's teaching and example have been handed down to us pure and unsullied by Albert Carless. It has, indeed, been an honour and a privilege to be associated with such a work. I wish its first collaborator well-earned rest and much happiness in that delightful spot, Crieff, where he has now settled.

Surgery is a progressive science, and it was naturally impossible for me to undertake the responsibility of such a publication without first-class assistance. My friend and colleague, Mr. John Hunter, has collaborated with me in this edition, and his opinions and advice have proved of inestimable value. Dr. Carnegie Dickson has kindly revised the earlier chapters dealing with Bacteriology, Inflammation, Immunity, etc. Mr. V. E. Negus has brought up-to-date those chapters concerned with the Surgery of the Ear, Nose, and Throat. Mr. Bishop Harman has written a chapter on the Surgical Affections of the Eye, which I feel sure will be of great assistance to students and practitioners. Another valuable contribution is a chapter on Tropical Surgery, by Sir Frank Powell Connor, which is new to this edition, tropical conditions formerly being dealt with piecemeal throughout the book. Mr. Eardley Holland has rewritten the section on the Surgery of the Female Genital Organs, and Dr. Charles F. Hadfield has revised the chapter on Anæsthesia. The Radiographic Supplement, for which Dr. Graham Hodgson is responsible, is entirely new. It is a real pleasure to record my thanks to these collaborators for the wealth

of new material which they have enabled me to add to this edition.

It has naturally been my constant aim to prevent any increase in the size of the book, and in spite of the inclusion of these new chapters, its bulk has been but slightly augmented.

In a textbook which is written for students and practitioners, it is essential that the illustrations should be numerous and of good quality. Many new illustrations have been used in this edition, including five in colour and over thirty in the Radiographic Supplement, and most of them have been specially drawn by Miss Mary Barclay-Smith, to whom I now offer my warmest thanks for the skilful way in which she has carried out this part of the work. The microscopic drawings are the work of Mr. Richard Muir, the well-known Demonstrator of Pathological Technique in the University of Edinburgh. His drawings, both coloured and line, are as perfect as it is possible to get them, and I wish to thank him for his great assistance.

The publishers have done everything in their power to ensure that the technical side of the production of the book and the illustrations shall be of a high standard. To the furtherance of this end the format has been altered and the general appearance of the volume modernized. The size of the page has been increased, and the binding has been changed from the old-fashioned crushed back with black lettering to a maroon cloth with gold letters. I feel sure that these innovations will be approved, and am glad to take the opportunity of thanking most sincerely the publishers (and I might also add the printers' readers) for the great assistance they have been to me in seeing this edition through the press. No one who has not had to deal with the production of a large textbook can realize the mass of detail involved, and the numerous pitfalls from which the publisher can do much to safeguard the author. The cross-references and figure references alone in this work run into thousands, quite apart from the index.

It has been my endeavour to bring the text completely up-to-date, and the modern use of radium in the treatment of malignant disease has received due recognition. The injection treatment of varicose veins and hæmorrhoids, the Winnett-Orr treatment of compound fractures, and the tannic acid treatment of burns, are a few of the new subjects which have been incorporated.

CECIL P. G. WAKELEY.

24, QUEEN ANNE STREET, W. 1.
August, 1930.

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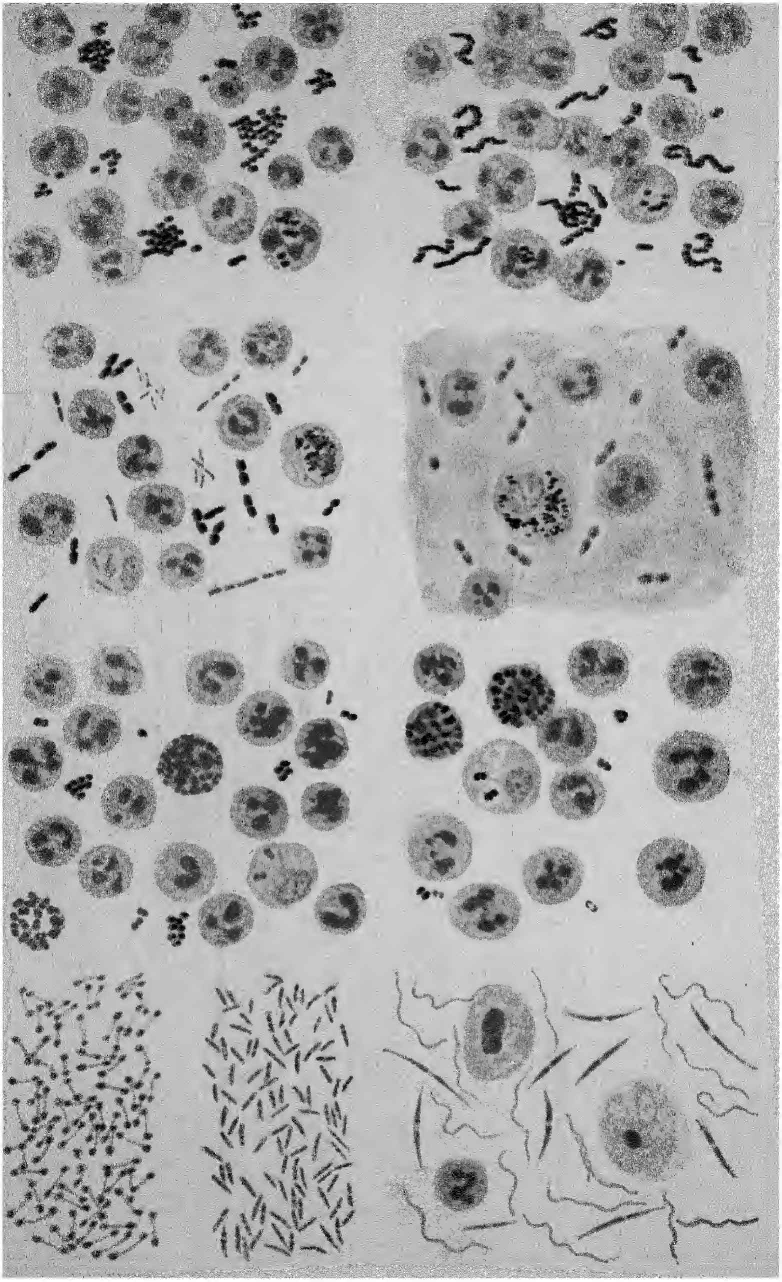

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PLATE I.

Fig. 1.—Film of Pus containing Staphylococci, showing the Gram-Positive Cocci in Typical Bunches.

A small mononuclear cell contains the remains of an ingested pus-cell. (Gram's Stain, × 1000.)

Fig. 2.—Film of Pus, showing Short Chains of Streptococcus Pyogenes for Comparison with Fig. 1.

A few cocci have been englobed within the cells. (Gram's Stain, × 1000.)

Fig. 3.—Film of Sputum, showing Mixed Infection with Gram-Positive Pneumococci, and Gram-Negative Friedländer's B. pneumoniæ (Larger) and Pfeiffer's B. influenzæ (Smaller Bacilli).

(Gram's Stain, × 1000.)

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Fig. 7.—B. diphtheriæ.

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Fig. 8. — Hofmann's Pseudo-diphtheria Bacillus.

Film from young blood-serum culture, showing 'barring,' but absence of metachromatic granules. (Acid Toluidin Blue Stain, × 1000).

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A couple of surface squamous epithelial cells and a pus-cell are also shown. (Leishman's Stain, × 1000.)

A MANUAL OF SURGERY

CHAPTER I.

BACTERIOLOGY—INFECTION—IMMUNITY.

REVISED BY W. E. CARNEGIE DICKSON, M.D., B.Sc., F.R.C.P.E.

THE importance to the surgeon of a study of bacteriology is twofold. In the first place, many surgical diseases (especially those of an inflammatory nature) are due to the action of bacteria; secondly, these organisms are practically ubiquitous, and in the absence of suitable precautions will inevitably enter any external wound, whether accidental or operative, and by their development and the inflammatory troubles which result therefrom delay the process of healing, or even give rise to fatal results. Hence every surgeon must have a general knowledge of the habits and distribution of the more important species of bacteria, their mode of life, and the mechanism by which they give rise to morbid processes in the human body, as well as of the methods used in their investigation. It was only by means of such knowledge that the present methods of treating wounds were evolved, and without it these methods cannot be intelligently applied in actual practice. Moreover, the diagnosis of disease is often much assisted by the bacteriological examination of morbid products, and its cure furthered by the use of vaccines and antisera.

Bacteria (**schizomycetes,** or **fission fungi**) form a very important group of minute unicellular plants which multiply by simple fission. Although several thousand species have been described, comparatively few are of importance in medicine or surgery. They are devoid of organs except flagella, and contain no chlorophyll. Their structure is extremely simple, consisting of a delicate **cell-wall** (composed of a condensation of the body-substance) which encloses a mass of **protoplasm,** in which there may be one or more vacuoles and a few granules of unknown nature. External to the cell-wall there is sometimes a gelatinous **capsule,** which may serve to unite the bacterial cell loosely with its neighbours. When such capsules become very prominent, large numbers of bacteria may become embedded in a gelatinous mass, known as a **zooglœa.** Capsule-formation is of some importance in diagnosis; the pneumococcus, for example, possesses a well-marked capsule when it occurs in blood or morbid exudates, and may thereby be distinguished from many organisms otherwise resembling it.

Flagella are delicate filamentous extensions of the protoplasm, which occur in those bacteria which are possessed of spontaneous motility. They are sometimes of great length, but are always extremely thin, and are visible only after the use of complicated staining processes. Their number is of importance in diagnosis. The typhoid bacillus, for example, has usually from twelve to twenty flagella, but the closely-allied *B. coli* has from three to six.

Nothing akin to the sexual method of reproduction has been observed amongst bacteria. Multiplication occurs as the result of a process of **simple fission,** in which the cell becomes divided by a thin membrane into two portions, which develop into mature organisms. The two bacteria thus produced may be entirely separated from one another, or may remain connected by means of the capsules described above, thereby remaining united into groups, which are more or less characteristic of the species. This process of division may take place with great rapidity, so that a suitable material which has become infected with one or two bacteria may contain vast numbers in the course of a few hours.

In many of the rod-shaped bacteria (bacilli), **endogenous spore-formation** occurs, not more than one spore developing in each cell. A spore may be looked on as a resting-stage during unsuitable conditions of environment, and from it, when the conditions become favourable, a fresh generation develops. Spores are round or oval in shape, and consist of a thick wall filled with protoplasm, which contains less water than the mature bacterium, and has, therefore, a highly refractile appearance when seen under the microscope. The shape and size of the spores have much diagnostic value; thus, the bacillus of tetanus has an almost spherical spore, which is distinctly larger than the diameter of the rod in which it is formed; the spore of the anthrax bacillus is oval, and little or no broader than the rod itself. The position of the spore is also of importance. The spores of the tetanus bacillus are at its extreme end, giving the appearance of a drumstick; those of anthrax are central. They resist drying to a far greater extent than do the bacteria themselves. Anthrax spores have been preserved in the laboratory for twenty years without loss of viability or virulence, but asporogenous anthrax dies in a few weeks when dried. They are also very resistant to heat. Most bacteria (when moist) are killed when exposed to a temperature of 60° C. for half an hour, whereas many spores will withstand boiling for ten minutes or even much longer. Lastly, they are very difficult to kill by means of antiseptics. Anthrax spores can be killed by immersion in 1 in 20 carbolic lotion, but only after several days. Of the bacilli of chief interest to the surgeon *B. tetani*, *B. anthracis*, and *B. œdematis maligni* form spores, and of these only *B. tetani* in the body; those of glanders, tubercle, diphtheria, typhoid fever, leprosy, influenza, and soft sore are asporogenous.

The **Classification** of the bacteria is based, in the first instance, on their morphology, but, owing to the simplicity of the shape of the

organisms, morphological characteristics have to be supplemented by physiological and by staining and cultural properties in the definition of the separate species. Four groups are described—cocci, bacilli, spirilla, and spirochætes.

I. **Cocci** are organisms which are spherical, or nearly spherical. They constitute the simplest forms of bacteria, since but few species possess flagella, and spore-formation is unknown. (*a*) Micrococci are those forms in which there is no definite arrangement into groups. The term 'staphylococcus'—more properly the name of a species, *e.g. Staphylococcus pyogenes*—is applied to cocci in which the individual elements are arranged in clusters resembling bunches of grapes (Plate I., Fig. 1). (*b*) Diplococci (Plate I., Fig. 4) are arranged in pairs, the two elements arising from the division of a single coccus remaining in more or less close apposition; many of them, however, develop into chains on culture. (*c*) Streptococci (Plate I., Fig. 2) develop longer or shorter chains, like a necklace, owing to the successive planes of division in which the cocci are divided lying parallel to one another at right angles to the long axis of the chain produced. (*d*) In a few cases a coccus divides into two, which are again divided in a plane at right angles to the first, so that the four cocci which result lie at the corners of a square; these are called Tetrads. Lastly, (*e*) Sarcinæ are formed by three consecutive divisions in the three planes of space, so that the eight cocci which are formed lie at the corners of a cube, and the group resembles a bale of wool tightly tied in three directions. These cocci often divide again, and lead to the formation of composite masses.

II. **Bacilli** (Plate I., Fig. 7) have the form of straight or slightly curved rods. Spore-formation is common, and many possess flagella, and are therefore motile. The terms streptobacillus for those which remain adherent in chains, and leptothrix for forms which produce long threads, are convenient.

III. **Spirilla** are curved or spiral organisms which may have a single curve—*e.g.*, the comma-shaped cholera vibrio—or may have several curves. It is a group of little importance to the surgeon.

IV. **Spirochætes** differ from spirilla in containing more curves and in being flexible. They appear as long spiral organisms (Plate VI., Figs. 1 and 2), which commonly show three types of active movement—viz., progression, flexion, and rotation on their own axis. They have been classed by some biologists among the protozoa, but are probably more correctly included in the bacteria. The most important member of this group is *Treponema pallidum*, the causal organism of syphilis, but a large variety of other spirochætes are to be found, particularly in lesions of the mouth and genitalia.

Conditions of Life.—Bacteria resemble other plants devoid of chlorophyll in being unable to form protein from simple materials in the presence of sunlight, and have to be supplied with ready-formed organic nitrogen from animal or vegetable sources. Regarded from this standpoint, they may be divided into two classes

—the parasites, which can obtain their pabulum only from the living animal or plant, and the saprophytes, which are unable to do so, and flourish only in dead materials. The term facultative saprophyte is applied to those organisms which prefer a parasitic existence, but which will grow under suitable conditions in dead materials. The gonococcus is a good example; it multiplies readily in the living mucous membrane, but grows *in vitro* only with difficulty and on certain special culture-media. Facultative parasites, on the other hand, are organisms which grow best in dead materials, but which have the power of adapting themselves to a parasitic existence. It must be understood that the terms 'parasitic' and 'pathogenic' are not synonymous. A pathogenic organism is one that has the power of producing disease, and it may do so without entering the living tissues at all, as when putrefactive organisms gain access to a blood-clot in the uterus and cause toxæmia. A parasitic organism is not necessarily pathogenic, especially in the lower animals, since these frequently harbour blood-parasites without appearing to suffer apparent harm therefrom.

In addition to combined nitrogen, all bacteria require water, certain salts, and a suitable temperature for their growth. The necessity for a more or less fluid culture-medium must be borne in mind in surgical practice, and every attempt must be made by accurate co-aptation of parts, drainage, etc., to prevent the accumulation of putrescible material in wounds or body cavities, or, in other words, to keep them dry. This is well seen in dealing with the peritoneum, the absorptive power of which is one of the chief natural defences against peritonitis. In laboratory experiments large amounts of fluid cultures of pathogenic bacteria can be injected into the peritoneal cavity of animals without injury; the fluid is rapidly absorbed and bacterial growth ceases. If, however, the peritoneum is injured so that absorption is checked, the bacteria continue to grow, and fatal peritonitis results.

The requirements of different bacteria as to temperature vary greatly. The majority of those of importance in human pathology grow best at or about the body temperature (37° C.), but many forms, especially those which are commonly met with as saprophytes outside the body (such as *Staphylococcus pyogenes* and *B. coli*), grow well at 18° C., or even lower. Other forms flourish best at lower or higher temperatures than these, but they are not of pathological importance. Lower temperatures inhibit growth, but do not kill the bacteria unless applied for long periods. The destruction of bacteria and spores by heat has been already mentioned.

Light is injurious to almost all bacteria. This is especially the case with *B. tuberculosis*, which *in vitro* is killed after a very short exposure to sunlight and more slowly by diffused daylight.

Many pathogenic organisms require free oxygen for their development, and are spoken of as **aërobes.** A few, such as the tetanus bacillus, will grow only in the complete absence of oxygen, ceasing to develop, though still remaining alive, when that gas is admitted;

such organisms are called **anaërobes.** Bacteria which grow best in air, but which will also grow in its absence, are called facultative anaërobes, and those which grow best under anaërobic conditions, but are capable of some growth in presence of oxygen, are called facultative aërobes. In the living body both strict aërobes and strict anaërobes are capable of growth. Moreover, a strict anaërobe may grow in a fluid freely exposed to air in the presence of other organisms which have a great affinity for oxygen and rapidly absorb it. In this way tetanus bacilli may flourish in superficial wounds if other bacteria are present.

The simultaneous and co-operative growth of diverse types of bacteria in a wound (**symbiosis**) is an important element in not a few infections, and especially in those due to anaërobes, such as the tetanus bacillus and the *B. perfringens*.

Bacterial Products.—By their growth bacteria act upon the media in which they flourish, and thereby various substances often of great importance are produced. The chief of these are (1) acids, such as lactic, acetic, butyric, etc.; (2) alkalies; (3) gases, such as sulphuretted hydrogen, marsh gas, etc.; (4) pigments, such as the green colouring-matter produced by *B. pyocyaneus* and seen in the so-called blue pus; (5) aromatic substances, such as indole, phenol, and tyrosine; (6) alcohol and other similar bodies; (7) ferments—*e.g.*, diastase, invertase, and a ferment allied to rennin. A more important enzyme is one resembling trypsin and having the power of peptonizing protein material. It is produced by one of the commonest pyogenic organisms (*Staphylococcus pyogenes*), and plays some part in the destruction of the tissues in suppuration. Its presence or absence is ascertained by cultivating the organism on gelatin or coagulated blood-serum, either of which is digested or 'liquefied' if the enzyme is produced. (8) Certain crystallizable organic substances develop, of definite chemical composition, allied to the vegetable alkaloids, and spoken of as ptomaines. They have some poisonous properties, and were once thought to be of great importance in the production of disease, but are now merely of historic interest. (9) The true **Toxins** have not yet been isolated in a state of purity, though they have been thought by some authorities to have some features in common with the enzymes. They are intensely poisonous when injected into the blood or tissues, though innocuous (in most cases) when taken by the mouth. They are very unstable substances, the majority of them being readily destroyed by heat, peptic digestion, etc., and when kept in a state of solution gradually become inert. Their action is analogous to similar vegetable and animal poisons, *e.g.* ricin and abrin, snake-venom, etc.

Toxins are divided into two distinct classes: (*a*) Certain organisms, of which the most important are the bacilli of tetanus and diphtheria, produce soluble **exotoxins** which accumulate in the fluid in which they are grown, and not in the bacterial cells. (*b*) In the case of many other organisms, the specific poison appears to remain locked

up in the bodies of the bacteria, and is only given off under conditions which we are unable to reproduce experimentally; they are known as **endotoxins.** For example, the soluble products secreted by the tubercle bacillus have but little toxic action, whereas the washed bodies of the bacilli themselves are extremely poisonous.

The pathological effects of these toxins are highly diverse, but in nearly all cases they include the production of fever. Some are selective in their action, affecting only a certain class of cell—*e.g.*, the cells of the central nervous system in the case of tetanus. Others, such as those of the pyogenic bacteria, affect any tissues they may happen to reach. Under natural conditions the results vary with the amount of toxin present in the body, and with the susceptibility of the animal and of the tissues in question. Thus a very powerful toxin may immediately destroy the vitality of a part *en masse*, whilst one that is somewhat less intense in its action may kill the tissues after causing an acute inflammation. In another group of cases the inflammation may terminate in a slower but progressive molecular death of the tissues, followed by suppuration or fibrosis. A similar but still slower process leads to necrotic caseation. Finally, if a very feeble toxin acts for prolonged periods it may serve as a stimulant to growth and determine proliferation of the fibrous tissues, etc., without the development of any external signs of inflammation.

Distribution.—Bacteria are very widely distributed in nature. Their presence in the air varies greatly with circumstances. They are absent from the air of mountain-tops or mid-ocean, and present in vast numbers in towns. They are not given off by evaporation from the surface of liquids, *e.g.* sewage, containing them, and when suspended in the air are usually adherent to particles of dust or moisture. They are more plentiful in dry weather than in wet, and more abundant in occupied houses than in the open air. When the atmosphere of an enclosed space is kept at rest, the bacteria and dust gradually sink to the bottom and the air becomes sterile. It has been found that the air of schoolrooms contains far fewer bacteria when the scholars are sitting quietly than when they are allowed to move about—a fact which should be borne in mind by spectators at a surgical operation. Expired air is sterile, but in speaking and coughing minute particles of fluid are ejected, and are usually charged with an abundance of bacteria, which are frequently pathogenic, and constitute a source of danger. The bacterial content of water also varies greatly. That suitable for a public water-supply should contain but few bacteria, and pathogenic forms should be absent. Water from natural sources may contain so many injurious bacteria that a preliminary sterilization is absolutely necessary before its use for surgical purposes. Earth contains vast numbers of bacteria, and pathogenic varieties are frequently present, especially in soil that has been artificially manured, perhaps for generations. Anaërobic organisms of a virulent type, such as *B. tetani* and *B. perfringens*, are then not infrequently present, and thus tetanus

and gas gangrene often occur in wounds which have been brought in contact with soil.

The human skin teems with bacteria, like anything else which is exposed to dust and dirt. The majority of these organisms are present simply by accident, and are readily removed by washing. A few, however, are normal inhabitants of the skin, and are very difficult to destroy, as they penetrate deeply into gland follicles. Bacteria are also present in the alimentary canal from the mouth to the anus, the external auditory meatus, the inferior meatus of the nose, the conjunctiva, the anterior portion of the urethra, and the vulva. The superior meatus of the nose, the deeper portion of the urethra, and the upper part of the vagina in a virgin are in general sterile, as are also the healthy gall-bladder, together with the biliary and pancreatic ducts. The blood and deeper tissues in health are usually free from germs, but careful observations have shown that the escape of small numbers of bacteria from the alimentary canal into the blood and lymph is of not uncommon occurrence. Under conditions of health these bacteria do not find suitable conditions for continued growth in the body, and are soon destroyed in the blood; but when the general vitality of the body is lowered, they may persist and, finding a suitable foothold in an area of low vitality, may develop and give rise to pathological effects. This is probably the explanation of the suppuration that sometimes occurs in deep lesions, such as the subcutaneous rupture of a muscle or ligament, and it is termed auto-infection (p. 65).

Bacteria may also remain latent in the tissues for a considerable time without causing trouble, and then under suitable conditions suddenly be stimulated into activity. This is particularly liable to occur in cases of chronic and prolonged infection of irregularly shaped wounds which heal slowly by granulation. Bacteria are often imprisoned during the healing process, and may remain quiescent until some fresh lesion such as a secondary operation, or some grave depreciation of health, provides them with a new opportunity of development. This condition is also probably the explanation of the majority of the so-called cases of 'idiopathic' infections—*e.g.*, erysipelas and tetanus (pp. 136 and 143), the germs having been implanted as the result of a slight injury at some earlier period. There can be little doubt that *B. tuberculosis* can similarly remain latent in the body for years, and then may determine an outbreak of tuberculous trouble in some distant region. Thus a slight injury to the knee has often been followed by tuberculous disease, but the infection probably arises from the previous existence of tuberculosis in mesenteric or mediastinal glands where the organisms had been encapsuled. Similarly the spirochæte of syphilis may remain more or less quiescent in the tissues for many years, and give rise to serious disease long after the clinical symptoms of the original infection have disappeared.

A dangerous outcome of this possibility is that individuals may become the unconscious **carriers** of disease, transmitting the infec-

tion to many others—*e.g.*, typhoid bacilli may establish a lodgment in the gall-bladder, and every now and then some infected discharge may escape: typhoid and paratyphoid bacilli may continue in the urinary tract for months or years; the throat and naso-pharynx of an apparently healthy individual may contain *B. diphtheriæ* or the meningococcus; and *Entamœba histolytica* of dysentery may persist in the bowel wall for years. In this way an explanation is possible of many an outbreak otherwise incomprehensible, and it emphasizes the necessity for the careful bacteriological examination of suspects.

Certain micro-organisms other than bacteria require brief mention, but only a few of them are of surgical importance.

1. The *Saccharomyces*, *Torulæ*, or *yeasts* are devoid of chlorophyll, and multiply by budding, or under certain conditions by endogenous spore-formation. They are a very indefinite group, and the yeast-*like* fructifications, of allied organisms often found in pathological conditions, have frequently been mistaken for them. They are of importance in baking and brewing, and they cause many forms of fermentation—*e g.*, the alcoholic fermentation of various sugars. The only important disease now attributed to the yeast-fungi is **blastomycotic dermatitis,** which is characterized by multiple chronic lesions, resembling verrucous tuberculides.

2. The *Hyphomycetes*, or filamentous fungi, are characterized by the presence of a mycelial network of long fibres, and have a method of sporulation which is more complicated than that seen in the bacteria and yeasts. The following are the more important of their pathological effects:

Thrush, due to *Oïdium albicans*, an organism sometimes included in the blastomycetes, and called *Saccharomyces* or *Monilia albicans*.

Ringworm, which may be caused by *Microsporon Audouini* (the small-spored fungus), or the *Trichophyton* or large-spored fungus, of which there are several varieties.

Favus, caused by *Achorion Schönleinii*.

Pityriasis versicolor, due to *Microsporon furfur*.

Keratomycosis, or parasite ulcer of the cornea, is due to fungi of the *Aspergillus* type, and similar organisms may also affect the lungs (**pneumomycosis**), tongue, or the external auditory meatus (**otomycosis**).

The group *Streptothrix* may be regarded as the lowest of the hyphomycetes, and its members possess many similarities to the bacteria. They are of importance, since their pathogenic members give rise to the group of diseases known as '**actinomycosis.**' The streptothrices form long filamentous hyphæ, which are narrower than those of the higher fungi, and differ from the leptothricial filaments sometimes exhibited by some bacilli in that they show true branching. They form chain-spores, the protoplasm of the mycelial threads collecting in small masses separated by spaces in which the sheath is empty. These appear to be true spores, since they resist a temperature higher than that which kills the mycelium itself. The streptothrices are widely distributed, and many forms are known, of which but a few are pathogenic.

It is worthy of notice that the tubercle bacillus (as well as other organisms usually classified as bacteria) sometimes grows into long branching filaments. Hence some regard it as belonging to the streptothrices, and term it 'tuberculomyces.'

3. The *Protozoa*, or unicellular animals, are a group of considerable importance, since many tropical affections are due to members of this family. The life-history of many of them is not known in its entirety, but it has been traced out in some. **Malaria** and the **amœbic form of dysentery,** together with the **tropical abscess** of the liver associated therewith, are protozoal in origin. *Trypanosomes* are also of animal nature, and by their development in the body give rise to **sleeping sickness** and numerous other tropical diseases in man and lower animals.

Infection.

Infection may be defined as the entrance of living, virulent, pathogenic bacteria into the tissues of a region where they can grow, and whence their toxins may act on the tissues of the body. Certain points in this definition require explanation:

(1) It is interesting to notice that dead bacteria, especially dead tubercle bacilli, may cause pathogenic effects similar to those of the living ones. This, however, can scarcely be spoken of as infection, since one of the fundamental ideas of that process is that it can be transmitted from one sufferer to another indefinitely.

(2) The question of virulence is one of the greatest importance, since differing strains of the same organism may vary much in the degree of virulence, as may also the same strain under varying conditions. Thus, rabbits are often but little affected by the injection of large amounts of a pure culture of *Streptococcus pyogenes*, and yet it is possible so to exalt the virulence of the same strain that an extremely small dose (possibly a single coccus) may produce death. This exaltation of virulence is usually accomplished by 'passage' through a series of susceptible animals, each in turn being inoculated from the last; the disease appears more rapidly and runs its course more acutely in each instance up to a certain point of maximum intensity, which persists. Probably something of the sort occurs under natural conditions, for an organism taken directly from a patient is usually much more virulent than one that has been cultivated in the laboratory. Thus, a slight post-mortem wound infected from a case of streptococcal peritonitis is usually very severe, indicating a very high degree of virulence in the organism.

Cultures of an organism of diminished virulence are said to be attenuated. The artificial attenuation of pathogenic bacteria is a subject of great importance in connection with the production of immunity, and it may be laid down as a general rule that the cultivation of an organism under slightly disadvantageous conditions tends to diminish its virulence, and *vice versa*. For example, the anthrax bacillus grows best at 37° C., or thereabouts, and retains its virulence for long periods at this temperature, but if it is cultivated at 42° C. it becomes attenuated. Cultures thus treated constitute Pasteur's vaccine against anthrax; when injected into animals it causes transient ill-effects, but the animal becomes immune to the disease. The gonococcus is another organism whose vitality is much influenced by heat. Growing best at a temperature of 35° to 37° C., and capable of growth between 25° and 38° C., cultures are injuriously affected by a temperature of 40° or 40·5° C., and inasmuch as the normal tissues are not seriously harmed by such a degree of heat, it is possible to employ diathermy with the object of raising the local temperature of parts such as the prostate, cervix uteri, or deep urethra, as well as of joints, when infected with these organisms, and thereby attenuating their activities, and

enabling the tissues to deal effectively with them. Similarly, growth in a resistant animal also tends to produce attenuation of the virus of certain diseases.

(3) The organism must be pathogenic if infection is to occur, and by this we mean capable of producing disease in the animal in question. Thus, the inoculation of the gonococcus into the urethra of animals leads to no results, and infection does not take place. Hence two factors must be present: the organism must be virulent and the host susceptible.

(4) Lastly, an essential feature of infection is that the toxins of the organism must act on the tissues of the host. Thus, it is quite possible, and not uncommon, for streptococci to be present in the outer layers of the skin, and *B. diphtheriæ* in the mouth, etc., and yet for no harmful effects to arise, since either the organisms do not form toxins, or else these toxins do not affect the tissues. This is not infection, although in such cases any slight lesion or any condition leading to local or general lowering of resistance may bring it about.

The terms specific and non-specific as applied to infectious diseases also require explanation. A specific disease is defined as one which is always produced by a particular species of micro-organism, and by no other. Thus, tetanus is a well-marked pathological entity, always due to *B. tetani*, and may be taken as the type of a specific infection. Suppuration, on the other hand, is caused by many different species of bacteria, and is therefore termed non-specific. The boundaries of these divisions are constantly changing with the advancement of pathological research. The common process is for diseases which are apparently homogeneous to be split up into specific groups, each due to its own organism. Thus, ringworm is now known to be due to several different forms of fungus, and combined clinical and pathological research has shown that the conditions due to one variety differ in minute points from those due to another. Enteric fever, again, has been long known to be caused by a bacillus (*B. typhosus*) which was supposed to be specific; it has now been proved that other organisms (*B. paratyphosus A* and *B*) can produce conditions which are very similar to typhoid fever, and are known as paratyphoid fever A and B, but each of these has characteristic manifestations and is in a way specific. Again, actinomycosis was formerly thought to be a specific disease due to a single organism, but it has now been shown that several allied organisms may produce it. The reverse process is sometimes seen, several apparently different diseases being united together on the discovery of their cause. For example, malignant pustule and woolsorter's disease appear clinically to be quite distinct maladies; yet since it has been found that they are both caused by *B. anthracis* they can now be included as manifestations of one specific disease.

Local Infective Processes are those caused at the site of inoculation by the growth and development of the microbes. After a period

of incubation—which varies with different organisms, and during which we may imagine that they are struggling with the germicidal action of the tissues, and establishing their foothold in the body—the bacteria begin to grow and multiply, and by the deleterious products of their activity cause irritation of the tissues and varying degrees of inflammation.

These inflammatory foci may remain limited, or diffusion may occur by the bacteria spreading with more or less rapidity by continuity of tissue or along lymph channels; or the organisms may be widely disseminated through the body by the bloodvessels in the shape of emboli. A certain amount of constitutional disturbance may accompany these manifestations, due to the absorption of the toxins produced locally, whilst in some diseases the general toxic symptoms (or toxæmia) associated with some local mischief may be extremely severe, as in tetanus and diphtheria. Hence local infective processes may be classed in two divisions: (*a*) those in which there is but little or no general toxæmia, such as a soft chancre, a tuberculous abscess, or a mild attack of gonorrhœa; and (*b*) those in which the toxæmic condition is well marked, as in erysipelas, tetanus, diphtheria, etc., the character of the symptoms varying necessarily with the different toxins.

General Infective Processes are those in which the organisms develop and multiply in the blood-stream, so that inoculation of a normal person with the blood would almost certainly transmit the disease if a sufficient dose were introduced. Most of the bacteria producing local infection are capable of giving rise to these general diseases, and, indeed, in surgery we rarely see the latter without some local condition being present to explain its origin.

Immunity.

Under ordinary circumstances every living animal is constantly exposed to possible sources of infection. Bacteria are present in the air we breathe, in our food and drink, as well as on the skin and in the alimentary canal. It is obvious, therefore, that some potent natural means of resisting the attack of these organisms must exist, and it is only when these break down or are insufficient that infection occurs. This power of resisting the invasion of micro-organisms is termed immunity, and it is the exact opposite of susceptibility. Further, the process of natural cure of any infective disease is brought about by the production of such a degree of immunity (whether local or general) as shall suffice to destroy the causative bacteria. It is therefore obvious that the study of immunity is of the greatest importance in connection with the prevention and cure of disease, and the more so since the most potent artificial methods of accomplishing these ends are those which imitate, or stimulate, or give free play to, these natural processes.

Natural Immunity is that which is inherent in the constitution of the animal when born, and not due to any event taking place in its

life-history. Thus the lower animals are all naturally immune to gonorrhœa and many other diseases which affect man, whereas man is naturally immune to many diseases of the lower animals. In most cases natural immunity is general throughout all the members of the species, but this is not always the case; thus, some children are absolutely immune to vaccinia, though the vast majority are susceptible. Hence racial and natural immunity are not quite identical.

It must be clearly understood that there is no absolute standard of immunity, since the reaction of the tissues may vary from time to time between the highest degree of susceptibility and the highest degree of immunity. Thus, if several animals are inoculated with equal doses of the same bacterial culture, one may show no ill-effects; another may exhibit a slight amount of inflammation at the site of inoculation; a third may acquire a spreading inflammation, which may progress to suppuration or gangrene; whilst a fourth may develop a fatal general infection. Further, an animal may be highly immune to an organism of ordinary virulence, but at the same time highly susceptible to the same organism when its virulence is exalted.

Again, the immunity or susceptibility of any animal to a given bacterium is greatly influenced by external and internal conditions. A study of these conditions is of fundamental importance in the prevention of disease. Man possesses a very considerable degree of immunity to nearly all bacteria, and it is only when this immunity becomes lowered by general or local causes which depreciate the vitality that infection occurs.

Of the **general** causes which predispose to infection, cold and wet, especially if combined, are perhaps the most potent, but the method in which they act is still uncertain. Starvation and malnutrition are also important, and even in slight degrees have a very decided effect on immunity. Thus, it has long been recognized that post-mortem wounds received when fasting are more dangerous than those received when digestion is in progress. In this case the immunity may perhaps be correlated with the increased number of leucocytes in the blood during digestion, but it does not appear to be a constant fact that a large number of leucocytes always implies a high grade of resistance, and *vice versa*. Age is an important factor, children being, as a rule, much more susceptible than adults. Immunity is greatly reduced by hæmorrhage, and by certain poisons, particularly alcohol. Protracted exposure to a vitiated atmosphere is a very potent factor in the production of susceptibility to the tubercle bacillus. Prolonged anæsthesia lowers the general resistance of the body, as do also certain diseases, notably Bright's disease and diabetes.

The **local** causes include injury, especially bruises, contusions, burns, and the irritation due to chemical substances. This latter condition is often used in the laboratory to exalt the virulence of certain bacteria. Thus, pyogenic cocci are often without effect

on rabbits, even in tolerably large doses; but if injected together with some dilute lactic acid, the toxins of other bacteria (such as *B. prodigiosus*), or other soluble irritant, they are frequently enabled to develop and produce pathological results. Considerable surgical importance is attached to this observation, since it must not be forgotten that nearly all antiseptics are irritant, and if applied in too concentrated a state or for too long may lower the local resistance, and render the wound more liable to be infected by any organism that may at the time or subsequently gain accidental entrance. The local application of cold or hot liquids has a similar action, and hence all fluids used to wash out wounds or body cavities should be used exactly at blood heat, unless the direct effect of the heat or cold is required. Lastly, a defective supply of fresh blood, due to disease in the bloodvessels, or stagnation of venous blood, due to tight bandaging, pressure, etc., also renders a part less resistant to infection.

Acquired Immunity is of two kinds—active and passive.

Active immunity results from a previous attack of the disease, from a subinfection or repeated subinfections with a dose of organisms too few in numbers or too low in virulence to cause any actual disease, or, thirdly, from artificial inoculation. The exanthemata are good illustrations of diseases conferring an active immunity. The permanence of the resulting immunity varies greatly. With some infections, such as small-pox, second attacks of the disease are very rare, and the immunity is commonly complete and lifelong. With other infections, such as those due to pneumococci or streptococci, the immunity is of short duration. All intermediate grades are found.

The following are the most important artificial methods of bestowing active immunity: (1) Inoculation of the disease as it occurs in nature. This is of course a dangerous method, since the attack may be as severe as one acquired in the normal way. It was formerly practised as a preventive of small-pox before the introduction of vaccination. (2) Inoculation with the causal micro-organism in an attenuated condition, or with the virus containing it. Pasteur applied this method in the prevention of anthrax in sheep and cattle, the 'vaccines' employed being living cultures of *B. anthracis* attenuated by growth at 42° C. He also employed an attenuated virus for the prevention and treatment of hydrophobia (p. 149). In the case of vaccination against small-pox, the lymph employed contains a living virus (whether that of small-pox itself in an attenuated condition, or of a closely allied disease, being not yet finally established). (3) Injection of dead cultures of bacteria is used in the preventive inoculation against plague (Haffkine) and against typhoid fever (Wright). The cultures are killed by heat, and small doses injected subcutaneously. The result is a local inflammatory reaction of varying severity, together with general symptoms, such as fever and malaise. When these have passed off, the patient has acquired some immunity to the disease,

so that he is now able to withstand the injection of a larger dose, by which means the immunity is greatly increased. This method has now been extended to the treatment as well as the prevention of many other infective conditions. (4) Injection of the extra-cellular toxins of the causative organism is of the utmost value in immunizing the lower animals for the preparation of curative sera, especially antidiphtheritic and antitetanic. The horse is chosen for this purpose, since it is easy to handle, and yields a large amount of serum at each bleeding. The principle of the method is simple. A small quantity of the toxin (which has been filtered to remove living bacteria) is injected subcutaneously. It causes local inflammation, fever, and malaise; but when these have subsided, another and slightly larger amount of toxin can be tolerated. In this way the dose is gradually increased until the animal is so resistant that the injection of enormous doses of most powerful toxin will produce but slight and transient ill-effects. In actual practice this method is usually modified, the earlier stages being considerably shortened by the injection of a mixture of toxin and antitoxin, or by the use of peculiar forms of toxin of diminished activity. A very satisfactory method of immunizing the human subject to diphtheria has been found in the injection of toxin (or modified toxin) and antitoxin.

It will be noticed that in all these methods the animal which subsequently becomes immune combats and overcomes the organism or its toxin. For this reason it is termed an active immunity—*i.e.*, it is acquired by the animal's own active struggle against and victory over the bacteria or their products.

Passive immunity is that which is conferred on an animal without effort on its part by the injection of serum from an animal that has already acquired an active immunity against the disease in question. For example, if some of the serum from a horse which has been actively immunized against tetanus is injected into a second horse (or other animal), the latter will also become temporarily immune to the tetanus bacillus or to its toxin. The second animal is not rendered ill by the injection, and is merely the passive recipient of protective substances which have been elaborated by the first. The fact that the injection of these sera into man sometimes causes transient ill-effects, such as fever, joint-pains, rashes, etc., in no way modifies the truth of this statement: the phenomena in question do not always occur, and are due, not to the protective substances, but to the ordinary serum proteins injected with them.

Passive immunity cannot be bestowed by the injection of serum from an animal which is naturally immune: most of the lower animals, for example, are naturally immune to syphilis, but their serum has no protective or curative action in man. The diseases in which the serum has the greatest practical value for protection or cure are those in which the specific micro-organisms produce extracellular toxins, especially diphtheria and tetanus.

Active and passive immunity also differ in other respects. Passive immunity is produced immediately the serum is injected, whereas active immunity is only developed slowly after the injection of the toxin, or of the living or dead culture; in general, a week at least must elapse before the full degree of immunity is produced. Again, passive immunity lasts a comparatively short time, unless, of course, the dose of the immunizing serum is repeated. In the case of prophylactic injections of antidiphtheritic or antitetanic serum in man, the duration of the immunity is probably less than a month. Active immunity is usually much more lasting, though its duration varies greatly in different cases. In most cases of small-pox and the other exanthematous diseases it is permanent, second attacks being extremely rare, whereas in pneumonia and erysipelas it is of very short duration.

Nature of Immunity.—It is obvious that the victory of the body over bacterial invasion is due to the development of immunity, either local or general, and without going into details, more suitable for a bacteriological textbook, some account must be given of the powers inherent in the body on which the surgeon has to rely in order to effect the recovery of his patient.

It has been already pointed out that bacteria must not only gain entrance into the body, but must increase and multiply therein, since it can scarcely ever happen that a sufficient number to cause deleterious effects can be introduced at the original focus of infection. In order to multiply in the tissues, they must find there not only suitable food, warmth, and moisture, but also the absence of antagonistic or germicidal materials. Now, whilst the living blood-plasma does not assist bacterial growth, the blood-serum derived therefrom is an excellent culture-medium, and hence there is an abundance of nutriment available. The living tissues, however, do not submit passively to the growth in them of these foreign invaders; they possess certain powers of resistance, and these must now be briefly considered.

The injury produced by bacteria is effected by means of poisonous substances either formed by the germs as secretions (exotoxins), or contained within their bodies (endotoxins), and set free on their death or disintegration. The action of such toxins is seen (*a*) in local inflammation and destruction of tissues; (*b*) as general poisoning of the whole body, shown by fever and prostration; or (*c*) in the form of special affections of particular structures, as in the degeneration of peripheral nerves met with in diphtheria, or the disturbance of the central nervous system which accompanies tetanus or hydrophobia, resulting in spasms and convulsions. Certain organisms, especially some of the streptococci, possess also the power of breaking up the red blood-corpuscles (hæmolysis). Hæmolysis by micro-organisms of red blood-corpuscles occurring artificially in culture must not, however, be taken as a criterion of pathogenicity. For example, certain non-hæmolytic streptococci may be or become highly pathogenic. The majority of staphylococci, even of low virulence, and

many non-pathogenic organisms, are actively ' hæmolytic ' to red blood-corpuscles in a test-tube. The value of the reaction as an index of pathogenicity has of late been somewhat over-estimated; though it is often useful for purposes of laboratory classification of certain organisms.

In order to resist the attack, the cells of the body may either ingest and destroy the germs themselves, or may render them harmless by producing antidotes to neutralize their toxins. Inasmuch, moreover, as the contest may be prolonged, and much damage may be done to the tissues thereby (just as the ground over which armies have fought is torn up by trenches, shell-holes, and the like), the body must further possess the power of repairing the damage caused, or at least of patching up the injured parts.

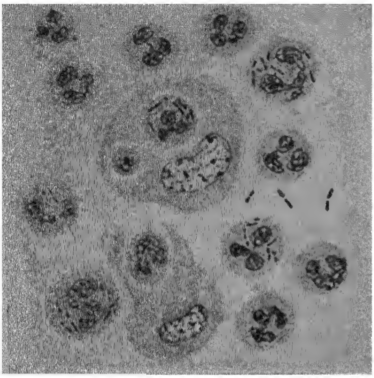

FIG. 10 —PHAGOCYTOSIS OF BACILLUS COLI BY CELLS OF PERITONEAL EXUDATE, TWENTY-FOUR HOURS AFTER INFECTION

The polymorphonuclear leucocytes (pus-cells) present in large numbers are actively ingesting the organisms, whilst the mononuclears, probably derived from the peritoneal endothelium, are englobing the pus-cells (× 1,000)

1. **Destruction of the Bacteria** themselves is effected by two main processes: phagocytosis and bacteriolysis.

(*a*) **Phagocytosis.**—Metchnikoff, starting from the idea that unicellular protozoa (such as the amœba) ingest, digest, and assimilate the bacteria found in water, was led to examine the action of the leucocytes, or wandering cells of the higher animals, which in their morphology so strongly resemble the lower protozoa, and found in them a similar power of engulfing and digesting living micro-organisms. This process he termed ' phagocytosis ' (Fig. 10). A striking example occurs in *Daphnia* (the fresh-water flea), an insect which is so transparent that the whole phenomenon can be followed under the microscope during life. It is affected with a disease due to the growth in its tissues of a fungus known as *Monospora*. The spores of this parasite are taken in with the food, and penetrate from the alimentary canal into the body cavity; when unchecked, they continue to grow until the whole insect is filled with growth. If, however, but few spores gain access, the defensive mechanism comes into play, and the spores are surrounded and engulfed by the leucocytes, submitted to a process of digestion, and finally destroyed. It is obvious that *Daphnia* is partially immune to *Monospora*, and that the immunity depends on the phagocytic activity of its leucocytes. Metchnikoff had no difficulty

in finding many examples of the same process in man and the higher animals. If, for instance, a culture of a non-pathogenic organism is injected into the peritoneal cavity of an animal, and portions of the peritoneal fluid are examined from time to time, the bacteria will be seen first lying free: then engulfed in the protoplasm of the leucocytes, but retaining their normal appearance and staining reactions: then less distinct and refractile than before, indicating that they have undergone partial digestion, and in this state they stain badly. Similar appearances may also be seen in sections of tuberculous tissue, especially those that are healing, though here the phagocytic cells are more especially the endothelioid or giant cells.

The leucocytes are attracted to the region of the bacteria owing to the fact that the latter give off soluble substances for which the leucocytes have an affinity, so that they move into the region in which these substances exist in a high state of concentration. This process is known as **chemiotaxis,** and it is one which is widely distributed throughout the lower members of the animal and vegetable kingdoms. If, for instance, a capillary-tube filled with meat-extract is placed in a watery emulsion of typhoid bacilli, the latter will be attracted by chemiotaxis and enter the tube. Similar phenomena are seen in the formation of an abscess: the pyogenic bacteria give off substances which attract the leucocytes, so that they soon become surrounded by a zone of these cells, and at the same time some of these substances gain access to the blood and attract the leucocytes from the bone-marrow, giving rise to a general leucocytosis. It has been suggested that very virulent bacteria can secrete special substances (aggressins), which repel the leucocytes and so preserve the germs against attack (Bail).

Metchnikoff found that in cases where phagocytosis was active recovery usually took place, and that when it failed the bacteria continued to grow and death occurred; from this he argued that immunity depends entirely on the leucocytes. He further noted that in animals with acquired immunity the leucocytes had gained the power of ingesting the bacteria, although previously unable to do so; hence he explained acquired immunity as being due to the education which the leucocytes had gained during the previous attack. The opponents of the theory urged that only dead, or at least non-virulent, bacteria were taken up by the cells, but Metchnikoff's great technical skill enabled him to isolate bacilli that had been actually ingested by leucocytes and prove them to be living and virulent.

The theory of phagocytosis was never generally accepted in its original form, and it was soon found not to apply in certain cases. Thus, it is possible to enclose active bacteria in a collodion sac, which will allow the transudation of body-fluids, but will prevent the passage of leucocytes; if such a contrivance is placed in the peritoneal cavity of an immune animal, the bacteria are often killed. Further research also showed that, even when bacteria are ultimately

destroyed by phagocytic activity, they may lose their definite outline, refractility, etc., and give other indications of being injured whilst still free and extracellular.

(*b*) **Bacteriolysis.**—The direct action of the fluids of the body in effecting destruction of the invading bacteria was definitely proved by Pfeiffer. This observer immunized guinea-pigs against the cholera vibrio, and when the immunity was fully established injected a culture of that organism into the peritoneal cavity. Some of the peritoneal fluid was withdrawn from time to time, and the organisms therein examined microscopically. They were found to undergo remarkable changes, losing their shape, becoming spherical, and finally undergoing complete solution, the whole process often taking half an hour or so. This is called **Pfeiffer's reaction,** and is specific—*i.e.*, the peritoneal fluid of an animal vaccinated against cholera has no effect on the typhoid bacillus or any organism other than the cholera vibrio or its congeners. Further research showed that the reaction can be obtained *in vitro*, provided that the peritoneal fluid is perfectly fresh; if, however, the fluid is kept a day or two, it loses its power, but regains it if mixed with perfectly fresh serum, whether this be taken from a normal or from an immunized animal. Thus:

Fresh normal blood-serum+cholera vibrios=no reaction.
Fresh serum (or peritoneal fluid) from immunized animal+cholera vibrios=solution.
Stale serum from immunized animal+cholera vibrios=no reaction.
Stale serum from immunized animal+fresh serum from normal animal+cholera vibrios=solution.

It is obvious from this that *two* substances are necessary for the solution of the organisms in the tissues of an immunized animal. One occurs only in the fluids of the immunized, not in those of a normal animal, and is an antibody similar to the agglutinins, but more complex; it has received many names, but is usually known as amboceptor. The other occurs in normal blood, as well as in the blood of the immune animal, and is very unstable, rapidly disappearing when the fluid is kept; it is also readily destroyed by heat. As its presence is required to *complete* such reactions, it is usually termed complement.

Certain other phenomena allied to bacteriolysis also require mention.

Hæmolysis.—Bordet discovered that if the blood-corpuscles of one animal are injected into another animal of a different species, the plasma of the latter acquires the power of dissolving red blood-corpuscles derived from any individual of the former species (hæmolysis). Similarly, if tissue-cells, such as those of glands or epithelial surfaces, are injected, the serum of the recipient gains the power of dissolving this particular type of cell, but not other cells, even from the same animal (cytolysis). The importance of

these phenomena in immunity is uncertain; but here also we may note that two substances are required—*viz.*, a specific amboceptor (hæmolysin or cytolysin) formed only in response to the injection; and, secondly, complement, which is identical with that concerned in bacteriolysis, and is present, though in very varying amounts, in all fresh sera.

Agglutination.—The serum of a patient who has suffered from an infective disease, or of one who has received a vaccine injection of the causative organisms, acquires in some instances the property of causing these organisms, when suspended in serum, to adhere together in clumps; it is said to 'agglutinate' them. This reaction is of considerable diagnostic value, for example in cases of suspected typhoid and allied fevers (**Widal's test**). Similarly, in the investigation of certain diseases, the agglutination reaction is employed by the bacteriologist to identify the causal organism. Thus in the investigation of bacillary dysentery various organisms may be isolated from the stools, and if one of these is found to be clumped powerfully by the patient's own serum, this affords strong proof that it is the infective agent. The agglutinins are also useful as proving the identity of an organism which has been isolated in culture. For example, if a culture of an organism resembling the typhoid bacillus had been isolated from the stools in a case of suspected typhoid fever (or from drinking-water, etc.), the first test applied to establish its nature would be to see if it is clumped with the serum of an animal which had been injected with a known culture of typhoid bacilli. The phenomenon of clumping is attributed to the presence of a specific antibody (agglutinin) in the blood-serum; unlike the lysins, the agglutinins do not require the presence of a second substance or complement to complete the reaction.

Precipitation.—If any foreign protein substance, such as egg-albumin or horse-serum, is injected into an animal, the latter develops in its serum an antibody (precipitin) which gives rise to a precipitate when it is mixed with a solution of the albuminous substance employed. The value of this reaction in immunity is unknown, but use is made of it in the investigation of blood-stains to distinguish human blood from that of other mammalia.

Any substance which, when injected into a living animal, gives rise to the production of a specific antibody (antitoxin, bacteriolysin, agglutinin, etc.) is called in this relation the **antigen.**

The precise origin of the different antibodies which take part in the various reactions just described is unknown. Possibly some of them are derived from leucocytes, and others from the cells of the tissues which form the red and white blood-corpuscles. It was noted by some of the earlier observers of the phenomena of immunity that the leucocytes (phagocytes) acted more energetically in the presence of serum than in its absence (Denys and Leclef). Wright and Douglas investigated this reaction in detail, and found that, whilst normal serum appeared to assist the cells to engulf bacteria,

the serum of patients recovering from an infection with the bacteria in question acted much more powerfully. Experiment showed further that the action of the serum was not in the direction of increasing the vigour of the leucocytes, but of modifying the germs in some way so that they were more easily engulfed and digested. The hypothetical substances which produced this effect were named **opsonins** (from *opsono*, I cook or prepare for food).

Wright devised a method by which the quantity of opsonin present in a patient's blood can be compared with that in the blood of a normal person. Thus it is possible to count the number of individual bacteria of any particular type which can be ingested by washed healthy leucocytes when mixed with a patient's serum, and the number ingested by similar leucocytes mixed with the serum of a known healthy individual, the two mixtures being kept at the

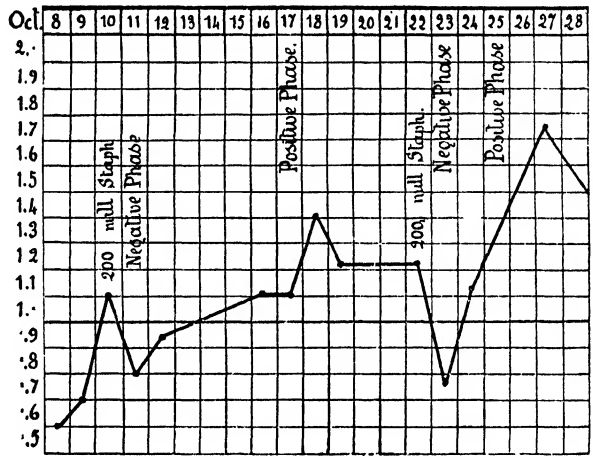

FIG. 11.—CHART OF OPSONIC INDEX IN A CASE OF INJECTION OF A STAPHYLOCOCCAL VACCINE.

body temperature for the same period of time. The ratio between these two numbers is termed the **opsonic index**.

As a general rule, in cases of acute disease it is found that the index is below normal, and that as recovery occurs it rises to or above the healthy level. This rise may be sudden, as in most cases of pneumonia, or gradual, as is usually the case in furunculosis. It is not uncommon to see patients in whom, though the index is high, the disease is advancing, and this is especially the case in tubercle.

The effects on the opsonic index of the injection of a bacterial vaccine are interesting and instructive. After each injection there is a rapid fall in the opsonic level (the negative phase, Fig. 11), followed by a rise, the index usually going well above normal (the positive phase). The improvement is supposed to coincide with an increased amount of opsonin in the blood, and when this begins

to diminish a fresh injection may safely be given. A second injection should never be given during the negative phase, since, if this is done, the index falls still further, and danger of dissemination or rapid spread of the disease might arise.

Experience has, however, shown that the estimation of the opsonic index is unnecessary, and it is sufficient to rely for the recognition of the good or bad effects upon the clinical results—*e.g.*, diminution of fever, discharge, or pain, commencing healing of the wound, etc.—remembering, however, the cardinal principle that sufficient intervals should elapse between the injections.

Complement Fixation.—It was noted above that the complement which takes part in the different processes of bacteriolysis, hæmolysis, and cytolysis is one and the same. When a mixture is made containing antigen, amboceptor, and complement, the three substances react, the complement being used up in the process. Thus, if cholera bacilli, amboceptor, and complement are mixed together, as in Pfeiffer's experiment, the complement becomes fixed to the bacilli, and if we add this mixture to a suspension of red blood-corpuscles to which has previously been added some hæmolysin, but no complement, no hæmolysis will take place; whereas the addition of fresh serum containing complement would produce this result. In other words, the complement is able to perform either the reaction of bacteriolysis or the reaction of hæmolysis, but not both. This phenomenon of complement fixation is used for diagnostic purposes to test for the presence of bacteriolysins and other complement-fixing antibodies in a patient's serum. The antigen (*i.e.*, the suspected organism) is mixed with the patient's serum and with complement. If the patient is the subject of the disease caused by the organism used as antigen, his serum will contain antibodies to it, which will react with the antigen and the complement, and the latter will be used up or fixed in the process. If the patient's serum contains no antibodies to this infection, no reaction will occur, and the complement will remain free and active. The presence or absence of free complement is then tested for by adding to the mixture free blood-corpuscles and hæmolysin. If there is no antibody in the patient's serum, the complement will still be free to hæmolyze the red corpuscles (negative reaction); but if the patient's serum contains antibodies as a response to infection, the complement will already have been fixed, and there will be no hæmolysis (positive reaction). This test is used as an aid to diagnosis in gonorrhœa, tuberculosis, etc. In syphilis a test on similar lines (**Wassermann reaction**) is employed, but for spirochætes is substituted as antigen a colloidal suspension in normal saline of lipoids (alcoholic extract of normal heart-muscle and cholesterin). This substitution of lipoids for spirochætes in the Wassermann test is purely empirical.

2. **Neutralization of Toxins.**—We have thus far dealt only with the methods whereby the body attacks and kills bacteria and with allied conditions. It remains to consider the process by which neutralization

of the toxins of the bacteria is secured. This type of immunity is mainly associated with those bacteria forming soluble toxins which are carried all over the body by the blood-stream, while the germs themselves remain localized. Such are the bacilli of diphtheria, tetanus and botulism, while the poison of snake-venom also gives rise to an antidote of a specific nature in the body. Our knowledge of this subject is largely the outcome of Behring's investigations on passive immunity, especially in relation to diphtheria.

Antitoxins.—If diphtheria bacilli are grown in a suitable liquid medium and are then filtered off by passage of the fluid through a porcelain filter, the bacterium-free filtrate is highly toxic, and a small quantity injected subcutaneously will kill a guinea-pig. If, however, it is mixed with a suitable dose of the serum of a person who has recovered from diphtheria, no fatal result occurs, the serum of the convalescent patient contains an antidote or antitoxin. A much more powerfully **antitoxic serum** may be prepared by injecting a horse with rapidly increasing doses of the toxin, and the serum of such an immunized animal may then be used for the cure of the disease in man. Neither toxin nor antitoxin has ever been isolated as a definite chemical body, but a fixed quantitative relation holds between them, the same amount of a given antitoxic serum always just neutralizing a measured amount of a particular toxic solution, just as a given quantity of caustic soda always neutralizes the same amount of hydrochloric acid. Antitoxin formation has no relation to natural immunity, for the blood of an animal which is naturally immune, say to tetanus, does not contain tetanus antitoxin; but in recovery from tetanus in a susceptible animal the antitoxin appears in the blood. When this happens, any fresh toxin that the bacilli form will be immediately neutralized, and the latter will thereby be deprived of their power to injure the cells of the animal. In the production of passive immunity similar phenomena take place; the antitoxin artificially injected into the blood combines with the toxin and protects the cells from its action.

The practical applications of these researches into immunity are twofold: diagnostic and therapeutic.

The chief examples of their **diagnostic application** are (*a*) the agglutination reaction in the diagnosis of typhoid, paratyphoid, Mediterranean (Malta), and other fevers, etc., and in determining the causal relationship of a particular organism in bacillary dysentery and other diseases; (*b*) the complement-fixation test in syphilis (Wassermann's reaction, p. 21), tuberculosis, gonorrhœa, and a few other diseases; and (*c*) the use of toxins in the diagnosis of particular diseases, such as tuberculosis and diphtheria. Introduction into a patient suffering from a particular disease of some of the toxin of the bacilli which cause the disease often gives rise to local inflammation or general disturbance. Thus in a tuberculous subject hypodermic injection of a small quantity of 'old tuberculin' (the concentrated

filtrate of a broth culture of the tubercle bacillus) may cause a sharp rise of temperature, and sometimes headache, shivering, and pains in the limbs. The same preparation scratched into the skin gives rise to local inflammatory reaction (von Pirquet's test, p. 189), or, if dropped into the eye, causes severe conjunctivitis (Calmette's test, p. 189). A similar reaction is induced in those who are susceptible to diphtherial infection by introducing into the skin a small quantity of diphtheria-toxin (Schick's test, p. 140), a useful procedure, *e.g.* in institutions where children are collected together, by which it may be determined which of them need prophylactic treatment against the disease.

The **therapeutic applications** are very important, though there is still much to be done before their practical use is fully understood. The substances employed in prophylactic immunization, and in the curative treatment of disease, fall under three main headings:

1. **Vaccines** consist of emulsions of dead bacteria* which are injected—usually subcutaneously, sometimes intramuscularly or intravenously—with a view to influencing beneficially infections in other parts of the body due to a similar organism. Such injections stimulate the defensive powers of the tissues, not merely locally, but generally, the antibodies so produced being thus available in increased amount to antagonize or neutralize the organisms and their products at the site of the disease. It usually happens, however, that the reaction of a living tissue is much greater than the stimulus demands, and thus, just in the same way as a fracture frequently leads to a formation of callus greater than is necessary for ultimate repair, so a vaccine results in a development of antibodies greater in amount than is required locally, and the superabundance thus created is available to deal with infections in other parts of the body.

As used curatively, they are prepared as follows: The organism is obtained in a pure condition from the patient to be treated, and a young culture is emulsified with sterile normal saline solution, and sterilized by being heated to a suitable temperature—*e.g.*, 60° C. for an hour. The number of bacteria per cubic centimetre is then ascertained (there are several methods by which this can be done), and the emulsion diluted with a sterile 0·25 or 0·5 per cent. solution of lysol or carbolic acid in normal saline solution. The degree of dilution has, of course, to be determined by the strength of the original emulsion, and by the number of bacteria which it is desired to administer in each dose. This varies greatly with different organisms; thus staphylococci are usually tolerated in large doses (increasing to 500 million or more), whereas *B. coli*, though individual strains vary greatly in virulence, in large doses may cause severe local and general symptoms, and the number given should be smaller. As a rule the patient acquires some degree of tolerance, and the dose

* Vaccinia, or cow-pox vaccine, from which the generic term 'vaccine' was originally derived, contains the *living* micro-organism—a filter-passer—of that disease.

may usually be increased gradually or more rapidly as the treatment progresses.

It is always advisable, where practicable, to prepare the vaccine for each patient from the organism which is attacking him (**autogenous vaccine**), since there are minute differences between the various strains of bacteria, and a ready-made vaccine may not prove efficacious against an infection with, apparently, the same species. This is less important in the case of the staphylococci, more so in dealing with the streptococci and *B. coli*. As, however, the vaccine takes a few days to prepare (having to be tested for sterility), it is sometimes useful to commence the treatment with a small dose of a stock vaccine. Another point of great importance is that many infections are due to more than one variety of organism, *e.g.* streptococci may also be present along with staphylococci in boils and other suppurative conditions, or along with *B. coli*, etc., in genito-urinary infections; catarrhal conditions, *e.g.* of the throat, are often due to multiple organismal infection, and so on.

Of recent years evidence has accumulated to show that, in addition to their action in stimulating the production of specific antibodies (opsonins, agglutinins, etc.), vaccines may also have non-specific effects. Wright and his co-workers and others have shown that, following the subcutaneous or intravenous inoculation of a suitable dose of vaccine, marked increase in the bactericidal power of the blood is produced, which reaches a maximum within about four hours. This bactericidal action is non-specific; an injection of 1,000 million killed staphylococci increases the bactericidal power of the blood against all organisms indiscriminately. This rapid production of bactericidal substances, which have been demonstrated in the laboratory, furnishes us with an explanation of the immediate improvement sometimes seen in febrile conditions after inoculation of a small dose of a vaccine—an improvement which occurs much too soon to be due to any specific immune bodies, since these require a week or ten days for their production. This phenomenon is also utilized in **immuno-transfusion.** A healthy donor of an appropriate blood-group is inoculated with a large dose of a vaccine, which may be of any organism, but usually staphylococci (1,000 million) are employed. Five hours later, when the bactericidal substances are at a maximum, the donor is bled, and 500 to 700 c.c. of his defibrinated blood are injected intravenously into an acutely ill patient whose response to his infection is failing. The addition of the healthy leucocytes and blood rich in bactericidal substances may enable him to cope with the infection. A non-specific effect of a vaccine—probably of the nature of protein shock—is also utilized in treatment of some more chronic conditions, such as rheumatoid arthritis, asthma, disseminated sclerosis, etc. Here a large dose of vaccine sufficient to cause a sharp febrile reaction is administered. With the pyrexia is associated a considerable polymorphonuclear leucocytosis. The beneficial effect seems to be proportional to the severity of the reaction, and it is the actual fever and leucocytosis that cause

the improvement rather than any stimulation of antibody production.

The use of vaccines must not be looked upon as replacing surgical treatment, but as an adjunct thereto. Abscesses must be opened and drained, dead bone removed from the bottom of a sinus, etc., septic teeth extracted or tonsils enucleated, etc., but the use of a suitable vaccine may often greatly aid the process of healing and shorten the convalescence. In cases which are not amenable to surgical treatment, or in which the surgeon desires to wait for a time before operating, this treatment should be tried whenever possible. Boils, however, may often be aborted in a most striking manner by an injection of 250 to 500 million staphylococci.

2. **Antitoxic Sera** in common use are prepared against the toxins of tetanus, diphtheria, and some varieties of bacillary dysentery. These, as has already been explained, contain substances which neutralize the extracellular toxins of the organisms in question: the problem of preparing potent antitoxins for the intracellular toxins has not yet been solved. The main point to notice in the use of antitoxic sera is that they will render the toxins inert, provided that they are brought in contact therewith before the latter have combined with and injured the living cells; hence the importance of their early administration in sufficient amount. Time may be saved by intravenous injection, since it has been found that diphtheria antitoxin is not fully absorbed from the subcutaneous tissues for twenty-four hours or more. The process is simple. The serum is warmed to body-heat and sucked into a suitable sterile syringe. The skin over a large vein of the forearm is prepared as for an operation, and the vein itself rendered prominent by obstructing the circulation, *e.g.* by a blood-pressure armlet round the upper arm. All air is removed from the syringe and needle, and the latter introduced obliquely at the side of, and about ¼ inch from, the distended vein. It is pushed gently on until the vein is entered, when blood can be drawn into the syringe. As soon as this happens, the pressure of the armlet is released, the piston pushed down, and the antitoxin injected slowly into the circulation.

3. **Antibacterial Sera** contain antibodies which act, not upon the toxins, but upon the organisms themselves, by (1) bactericidal or bacteriolytic action, (2) opsonic action, and (3) agglutination. The results obtained by their use are not so striking as in the case of the antitoxic sera, but they should be given a trial in cases of severe infection. Of these sera the most important in surgical practice are:

(*a*) Antistreptococcal Serum, which is prepared by immunizing horses with living cultures of *Streptococcus pyogenes*. A polyvalent serum prepared by employing a variety of strains is commonly utilized. Recent work, however, has shown that though there are innumerable strains of *S. salivarius* and *S. fæcalis*, the hæmolytic streptococci (which are responsible for the more acute surgical streptococcal lesions, cellulitis, erysipelas, etc.) belong with very few exceptions to a single serological type, and a monovalent serum is,

therefore, equally effective against these particular varieties of streptococcal infection. The dose of serum administered may be 20 to 50 or 100 c.c., subcutaneously or intravenously, and this may be repeated as often as necessary. A transient rise of temperature (due possibly to solution of the streptococci and liberation of their toxins) is not necessarily a bad sign, and is often followed by a marked improvement. It should be noted, however, that certain of the non-hæmolytic streptococci may attain a considerable degree of virulence, and may be found in broncho-pneumonia and in some cases of puerperal fever, and in subacute infective endocarditis, etc., or along with other organisms such as staphylococci, *B. coli*, etc. (see p. 61). A specific antiserum is now also prepared against the streptococcus of scarlet fever, for prophylactic and therapeutic, as well as diagnostic, use.

(*b*) Anti-anthrax Serum, of which the best known in this country is that prepared by Sclavo. This has given excellent results in the treatment of localized anthrax (malignant pustule), and the improvement is often manifested within twenty-four hours. It should be given intravenously.

(*c*) Anti-pneumococcal Serum.—Before commencing treatment with this serum, the type of pneumococcus present should be determined. If the infection is with Type I. pneumococcus, good results may be expected by treatment with large doses of Type I. antiserum intravenously. The results obtained with Type II. antiserum are not so good, and to the remaining types of pneumococcus efficient antisera have not yet been prepared.

(*d*) Anti-dysentery Serum.—The action of this serum is probably partly antitoxic, and partly antibacterial. It is usually prepared in polyvalent form, and should be used for the treatment of ulcerative colitis due to dysentery bacilli.

There are numerous other sera, which do not call for notice here.

Anaphylaxis and the closely allied phenomenon known as **allergy** are conditions of supersensitiveness to foreign proteins, such as the serum of another animal, egg-albumin, grass-pollen, etc. Supersensitiveness manifesting on the administration of a subsequent dose of an antiserum is usually the result of an injection ten days or more previously of serum from the same species of animal (commonly the horse), and depends on the ordinary serum proteins, not on the antibody content. If a minute quantity (0·001 or even, in some cases, only 0·000001 c.c.) of horse serum be injected into a guinea-pig, the animal will become sensitized to horse serum. If, after an interval of not less than twelve to fourteen days, a second dose of 5 c.c. (non-toxic to a normal guinea-pig) be then injected intraperitoneally, or one-tenth of that dose intravenously (subcutaneous injection being more uncertain in its results), the condition of acute anaphylactic shock rapidly supervenes with collapse, dyspnœa, and frequently death. The symptoms appear to be due to a toxic effect on smooth muscle. Man is much less susceptible

than the guinea-pig, but anaphylaxis may occur as the result of a previous injection ten days to six months or more before, or rarely in horse-asthma patients with no history of previous injection. Acute anaphylactic shock in man causes extreme distress, with dyspnœa, cyanosis, and collapse; death may ensue, but the number of fatal cases on record is very small. If there is any reason to suspect supersensitiveness, the patient should be tested beforehand by injecting intradermically, not hypodermically, a small amount, *e.g.* 0·1 c.c. of the serum. If no urticarial or erythematous reaction occurs round the site of injection within forty minutes, the administration may be proceeded with; but, should a positive reaction, which usually occurs in from five minutes to half an hour, be obtained, desensitization must first be effected. If there is no urgency, 0·025 c.c. of serum should be administered hypodermically suitably diluted with saline, and the dose should be doubled every half-hour. If no reaction follows when the amount of 1 c.c. is reached, the following doses are given intravenously, beginning with 0·1 c.c., and doubling the dose every half-hour until the total amount of, say, 25 c.c. has been given. In urgent cases—*e.g.*, in tetanus—a more rapid method must be adopted, even though it entail some risk. A War Office Committee recommended the following method: 5 c.c. of the serum are diluted with 50 c.c. of normal salt solution. Of this mixture, 1 c.c. is injected intravenously, followed four minutes later by 3 c.c., two minutes later by 10 c.c., and two minutes later again by 25 c.c. Then in ten or fifteen minutes the full dose may be given intravenously or intrathecally. All such injections must be given very cautiously and slowly. If any reaction occurs during this procedure, the administration must be delayed. In cases where anaphylactic shock has developed, atropine sulphate ($\frac{1}{50}$ grain) or a 1 in 1,000 solution of adrenalin (0·3 to 0·5 c.c. or 5 to 8 minims) should be given intravenously in 10 c.c. of sterile normal saline.

Serum Disease, apart from the more serious phenomena described above, under acute anaphylaxis, is another condition which may follow the administration of a foreign serum, and is probably an analogous phenomenon. Its frequency and intensity are in direct relation to the volume of serum given. The first symptom is usually an urticarial or erythematous rash, which appears between the seventh and tenth day at the site of injection, and may become generalized. This may be accompanied by malaise, slight fever, adenitis, pains and effusions into the joints, and albuminuria. The condition causes considerable discomfort, but is never serious, and recovery occurs within a few days. It is stated that intravenous injection of 1 to 2 c.c. of the patient's own serum causes rapid disappearance of the symptoms. Calcium lactate in 15-grain doses at the time of the injection and for a day or two subsequently may be given as a prophylactic measure, but is not of great value. Otherwise the treatment is purely symptomatic. An **immediate** reaction may occasionally supervene after a **second** injection, almost at once or within six hours; or an **accelerated** reaction may occur

between the eighteenth hour and the fifth day, with the appearance of rash, joint-pains, vomiting, pyrexia, and even convulsions and collapse.

Allergy, which is a condition probably closely allied to anaphylaxis, is the supersensitiveness, exhibited by some patients suffering from certain diseases, to the products of the corresponding organism —*e.g.*, tuberculin or mallein in tuberculosis and glanders respectively. This state is probably gradually produced by the bacterial products set free within the body of the patient; and, in a similar way, hay-fever, hypersensitiveness to various food-proteins, both animal and vegetable, hairs, feathers, and other epidermal structures or débris of animals, etc., is probably due to previous sensitization by the absorption of grass-pollen, etc., or the other foreign proteins involved. In certain cases, the condition of supersensitiveness appears to be natural, rather than acquired. It may be hereditary, and run in families, and it may take different forms in the different members of such families.

CHAPTER II.

INFLAMMATION AND REPAIR.

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THESE two series of processes are so intimately intermingled and dependent upon one another that no advantage is gained by endeavouring laboriously to distinguish them one from another. In this series of processes sometimes one set, sometimes the other, may predominate, but in most cases a more or less definite sequence of events may be observed.

'Inflammation is the succession of changes which occur in a living tissue when it is injured, providing the injury is not of such a degree as at once to destroy its structure and vitality.' Such was the definition given in 1870 by Burdon Sanderson, and it is sufficiently accurate if it be remembered that the term 'injury' includes bacterial invasion; and that the 'succession of changes' is presumed to appear soon after the application of the injury. If such injury has not completely destroyed the vitality of the tissues or killed them outright, changes occur in and around the injured area, by which Nature endeavours to limit and localize the effects of the irritant; to antagonize, eliminate, or enclose it if still present; and to make good the damage, either by restoring the tissues to normal or patching them up as far as possible—casting off the débris if at a surface: absorbing and removing it if within the body; or, if this cannot be completely accomplished, transforming it to, or enclosing it by, fibrous tissue within the living tissues. In the past, a great variety of opinions existed as to the position of the dividing line between inflammatory and reparative processes. Occasionally the tissue reaction called into existence by bacterial invasion is so severe as to increase, rather than diminish, the risks of the patient.

The **causes** of inflammation are varied and numerous. Most frequently it is due to the admission of bacteria, and we have already alluded (p. 12) to the conditions, local and general, which predispose an individual to such invasion, and render him more liable to an inflammatory attack. Apart from bacteria, inflammation may be lighted up by (*a*) mechanical lesions, such as blows, sprains, tension, pressure, etc.; (*b*) burns or scalds; (*c*) the electric current, either in the form of lightning, or as applied by the surgeon, or through the agency of strong currents as employed for purposes of traction or illumination; (*d*) toxic bodies, such as acids, alkalies, or vegetable and animal poisons; and (*e*) the irritating influence of X-rays, radium emanations, sunlight, ultraviolet rays, etc.

The actual **phenomena** of inflammation are perhaps best studied in the web of a frog's foot. If this is spread out and examined under the microscope, the following evidences of normal physiological activity may be seen: (*a*) the flow of blood through the vessels (Fig. 12), as indicated by the movement of the formed blood-elements—the red corpuscles, each separate from the other, flowing in the central or axial current; the leucocytes occasionally seen amongst the red, or here and there one may be noticed rolling lazily along in the inert corpuscle-free peripheral portion of the tube; (*b*) the constant rhythmical changes in calibre of the arterioles independent of the heart's action, and influencing in a marked degree the flow through the capillaries; and (*c*) the changes which occur in the pigment-cells, and are due mainly to the influence of light, the cells contracting or expanding as the light is increased or diminished.

I. The **Vascular Changes** in acute inflammation can be easily studied if a crystal of common salt, or some such irritant, is applied to the web. A transitory contraction may perhaps be noticed in the arterioles, but is of no known pathological significance. It is followed by a condition of **Hyperæmia** of the inflamed area, as manifested by a rapid and lasting dilatation of the vessels, accompanied by an increase in the rapidity of the blood-flow (**acceleration**); it is probably brought about by some change in the local vasomotor mechanism. This increased rapidity of the flow lasts for a while, and then the current gradually becomes slower and slower (**retardation**), as if an ever-growing obstruction existed to the passage of the blood; next a period of **oscillation** will be noticed, the crowded corpuscles swaying forwards and backwards, and finally a condition of **stasis** or standstill is arrived at, which may or may not end in actual **thrombosis** or intravascular coagulation. During this period the relations normally existing between the vessel walls and the varied constituents of the blood have obviously become modified, since, almost as soon as dilatation occurs, the leucocytes, and also the blood-platelets, collect along the walls in the periaxial inert layer, seeming, as it were, to fall out of rank; this process first commences in the veins, but can be observed in all the vessels. The red corpuscles also, which formerly had flowed along separately, now tend to fall out into the peripheral stream and to become more viscous, and may become fused together.

The second factor in the vascular changes, **Exudation of Lymph,** becomes evident at a very early stage, the amount and situation of the fluid depending partly upon the nature of the irritant, and partly upon the tissue or tissues affected. This inflammatory œdema may occur into a tissue meshwork, or, if the inflammation is at a surface, it may escape, or may collect, *e.g.* in a body-cavity. This exudation of lymph is merely an exaggeration of a normal process, but to such an extent that although for a time the lymphatics of an inflamed region do increased work, yet the transudate is soon greater than they can deal with. If the fluid escapes into the tissues, it may undergo coagulation if it meets the necessary coagulating media (fibrin-

ferment, etc.) developed from the breaking-down leucocytes, etc.; inflammatory lymph forms locally, whilst the serum collects in the meshes of the tissues, constituting an inflammatory form of œdema; if there is a sufficient breach of surface, the serum drains away. If the exudation takes place from a serous surface—*e.g.*, pleura, peritoneum, synovial membrane, etc.—the fluid collects in and may distend the cavity; it is at first spontaneously coagulable (*i.e.*, consists of plasma); if coagulation occurs, the clot or lymph either forms an adherent plastic mass on the surface or floats free in the fluid.

Emigration of Leucocytes.—It has been already mentioned that the **leucocytes** collect in the periaxial layer, a phenomenon due partly

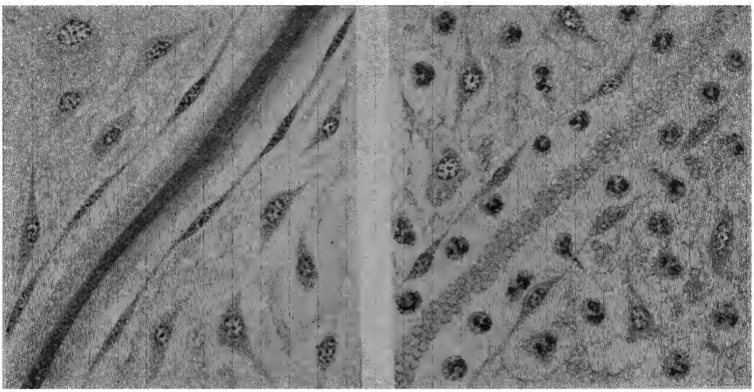

FIG. 12. FIG. 13.

THE VASCULAR PHENOMENA OF INFLAMMATION. (AFTER THOMA.)

On the left is a normal vessel with its peripheral layer free from corpuscles, and its axial stream so rapid that the individual corpuscles cannot be seen. On the right is a similar vessel in a state of inflammation; the blood-current has been retarded so that the individual corpuscles are visible; the leucocytes occupy the periphery of the vessel, and are in process of migration.

to an alteration in the vessel wall, whereby it is rendered more 'sticky,' and partly to chemiotaxis (p. 17). The next change consists in the passage of the leucocytes through the vessel walls, especially those of the smaller veins and less often of the capillaries. The process is a strictly vital one, brought about by active amœboid movement; a small extruded process of the leucocyte (pseudopodium) is inserted, usually between the endothelial cells lining the vessel, whose cohesion has been probably interfered with by the action of the irritant. Into this process the protoplasm of the leucocyte flows, still further separating the endothelial elements, and thus the cell passes through the wall into the surrounding tissues (Fig. 13). The **migration of the leucocytes** lasts only as long as the

blood in the vessel is actually circulating; as soon as thrombosis occurs, migration ceases. When the white corpuscle has escaped into the perivascular tissues, it may undergo various changes. In the first place, it may die and be at once disintegrated, setting free fibrin-ferment, and thus assist in the production of the inflammatory coagulum to be shortly described; or, again, it may be transformed into a pus-cell. It will also attack and assist in removing any dead tissue which exists in and around the inflammatory focus, whilst a phagocytic or microbe-destroying function is also subserved. In fact, the leucocytes may be looked on as the scavengers of the body, or as advanced guards, which, at the onset of mischief, are thrown out from the vessels as Nature's first line of defence against the invading forces, their chief duty being to remove all damaged and noxious material, and then, having limited the spread of the destructive process, they in turn give place to larger and more useful cells (fibroblastic) which are the active agents in the process of repair.

Passive Escape of the Red Corpuscles often occurs, especially in the more acute types of inflammation, and such hæmorrhages, smaller (petechial) or larger, are due to damage to the vessel walls. When once external to the vessels, the red corpuscles are broken up and their colouring matter diffused through the tissues, whence, as a rule, it is completely reabsorbed.

Looked at, therefore, simply from a vascular point of view,

Inflammation=
Hyperæmia+Exudation of Lymph+Emigration of Leucocytes.

Each of the elements in the inflammatory reaction is of service to the patient in combating an attack by bacteria and their toxins. The acceleration of the blood-flow brings an increasing quantity of blood to the part, and thereby helps to maintain the nutrition of the tissues at the highest level, so that, if possible, they may be preserved alive. It also assists by diluting and washing away the toxins, and provides a suitable quantity of antibodies or antitoxins, which are capable of neutralizing the action of the toxins or destroying the bacteria. The excessive transudation of the plasma may be regarded as an additional means of fulfilling these desiderata. The value of the retardation and stasis of the blood is less obvious, although it probably assists the emigration of the leucocytes, which might otherwise find difficulties in attaching themselves to the walls when floating freely in a rapid blood-stream. The extravascular rôle of the leucocytes has been already considered.

II. **Tissue-Changes.**—The reaction of the tissues in **acute bacterial** inflammations appears to depend on the one hand upon the irritative power and nature of the toxins, and, on the other, upon the power of resistance of the patient's tissues. It may be laid down as a general rule that any irritant, if weak enough (*e.g.*, when very diluted), acts as a stimulant to the function and growth of cells; on

the other hand, if more powerful, it will cause changes varying from slight degeneration up to complete necrosis or death of the tissues.

If the toxins are sufficiently active, death of the tissue may result. This is often brought about by the process termed **coagulation-necrosis.** In this condition, the tissues and cells become soaked in the coagulable plasma which exudes from the vessels, and the activity of the toxins causes coagulation and death of the whole mass. The result is that all structure disappears from the area involved: the nuclei cease to stain with hæmatoxylin or other basic dyes, and all the tissues stain uniformly with acid stains, such as eosin. The further history of the lesion depends on the nature of the causative organisms. If these are of a pyogenic nature, the necrotic mass becomes infiltrated with **polymorphonuclear leucocytes,** some of which are killed by the toxins, *i.e.* **suppuration** occurs, with softening and the formation of an abscess (see p. 66).

Mononucleated cells of various sizes and types appear in inflammatory exudates, sometimes earlier, sometimes later, and, for the full discussion of the nature and functions of these, reference must be made to the larger textbooks of pathology. It is sufficient to state here that the **large hyaline** or **endothelial cell** may be derived either from the blood or from tissue-endothelial cells. They often appear comparatively early in the course of many inflammatory conditions, especially of serous surfaces, and they usually increase progressively in numbers, as the condition improves, and as the polymorphs diminish in numbers. They are actively amœboid, and are concerned especially with the phagocytosis and removal of dead cells and débris, though they may also englobe bacteria. Later still, '**small round cells,**' regarded by many as identical with lymphocytes, appear, and may gradually replace the larger mononuclears, from which others believe them to be partially derived, as all intermediate sizes may be found in the same exudate, *e.g.* in a recovering pleurisy or meningitis. These 'small round cells' and also the closely related plasma-cells are found especially in chronic inflammations, and particularly in tuberculous and syphilitic conditions.

In any given case, the above described processes overlap and are intermingled in varying degree; whilst the processes usually classed under 'repair' may also supervene, early or late, according as the irritant and its effects are overcome and neutralized.

In the more **chronic** inflammations, active cell-proliferation is an important element in the process, resulting in **fibrosis** and induration of the parts. This mainly affects the interstitial tissues, and thereby the specialized structure of an affected organ may be impaired.

III. The **Terminations** of inflammation will therefore vary considerably with the cause of the trouble, whether bacterial or not, with the intensity and duration of its action, with the nature of the special tissues involved, and with the powers of resistance possessed by the individual.

In **bacterial** inflammations:—(1) Where bacterial infections are limited in area and slight in degree, and, especially if not affecting

the more highly specialized tissues such as brain (in which repair is usually very imperfect), there may be complete or practically complete **restoration to normal.** (2) Frequently, however, **local destruction of tissue** results, and, according to the nature of the bacteria and the tissues involved, this may be followed by (*a*) **repair,** the necrotic tissue disappearing and scar-tissue taking its place; (*b*) **suppuration,** in which the affected tissues and the exudate are liquefied and transformed into pus; evacuation of the abscess thereby formed gives exit to the bacteria, the exudate, and the necrotic tissue, and repair is finally brought about by the formation of granulation-tissue and its cicatrization; (*c*) **ulceration,** when the necrotic or suppurative process affects the surface; or (*d*) extensive **necrosis** or **gangrene,** when the toxic effects of the bacteria are able to break down the tissue-resistance to such an extent that the bacteria can diffuse themselves widely through the part. In this connection it may be noted that the specialized tissues of the more highly organized and important organs are always more vulnerable than the simpler forms of connective tissue, and this in spite of the fact that the former are usually better supplied with blood. Thus, the growing end of the diaphysis in a child is a most delicately organized region and hence is peculiarly liable to serious destructive inflammation from bacterial agents, which would do little harm if developing under similar circumstances in, say, the subcutaneous connective tissues.

Resolution, or the restoration of the part to its natural condition and function, can occur only when the injury has not been so severe as to destroy the vitality of the affected tissues. The phenomena are merely those of inflammation in a retrograde order—*viz.*, an oscillatory movement first manifests itself amongst the corpuscles, and then the blood-stream is gradually restored, slowly at first, and more and more rapidly afterwards. The adhesiveness of the corpuscles disappears by degrees, but it is some time before the peripheral inert layer can be seen. The exuded leucocytes find their way back into the circulation either through the vessel walls, or to a greater extent *via* the lymphatics, or else they are disintegrated in the tissues and absorbed. The fluid exudate is removed by the lymphatics. For some time after an acute attack the vessels of the part, especially the veins, are dilated from simple loss of tone, but this also gradually disappears.

In the artificial irritation produced by the injection-treatment of varicose veins, the thrombus so produced is gradually transformed into fibrous tissue.

Clinical Signs of Inflammation.

The **Local Phenomena** may be described under the four headings suggested by Celsus (about A.D. 50), *viz*,, ' calor, rubor, tumor, dolor' —heat, redness, swelling, and pain, with the addition of a fifth, *viz.*, impairment of function.

Heat.—An inflamed part feels hot to the touch, and the temperature, if taken by a surface thermometer, is definitely raised above

that of the surrounding skin. This is due to the increased amount of blood flowing through it, for the temperature of an inflamed area is never higher than that of the blood at the centre of the circulation, *i.e.* in the heart.

Redness is due to the hyperæmic condition of the inflamed part. In the early active hyperæmia the colour is a bright rosy-red, fading quickly on pressure, and returning with equal rapidity. During the period of retardation, the redness is more dusky, since the blood is longer in passing through the capillaries, and so loses more of its oxygen; the colour does not disappear or return so rapidly, and a slight yellowish tinge often remains from the presence of extravasated hæmoglobin. When stasis is reached, and *a fortiori* if thrombosis has supervened, pressure does not remove the red colour, and, should such a state persist for long, permanent pigmentation may remain.

When the tissue inflamed is non-vascular—*e.g.*, the cornea or articular cartilage—redness is of course absent until the part becomes permeated by newly-formed vessels. In the case of the cornea, however, a zone of deep pink injection is seen in the ciliary region. A similar absence of redness is observed in an inflamed iris, owing to the excess of pigment hiding the dilated vessels; if, however, the inflammation is very prolonged, the pigment may be absorbed, and the iris becomes obviously red.

Swelling arises from the same two causes, *viz.*, hyperæmia of, and exudation into, the part. Necessarily the amount of tumefaction depends upon the acuteness of the disturbance and the distensibility of the tissue, and in measure varies inversely with the amount of pain. Where the inflamed area is covered by a thick and firm fascia, not only is the tensive pain very considerable, but the chief swelling may occur away from the inflamed area, *e.g.* over the back of the hand in a palmar abscess. Where the inflammatory products escape into lax tissues, the subjective phenomena are diminished, although the swelling may be very great. Similar illustrations of the occurrence of œdema at a distance are to be seen in inflammations of the sole of the foot, and in the swelling of the eyelids when the scalp is inflamed. Swelling due to inflammation, though diminishing after death, does not entirely disappear.

Pain results from the mechanical irritation of the peripheral nerve-terminals, both by the increased arterial tension and by the pressure of the exudate, so that it is much greater if, from the density of fascial or fibrous investments, swelling cannot readily occur, *e.g.* in the palm of the hand, or in the eye or testicle. Possibly the exudate may have some direct chemical action on the nerve-terminals, especially when destructive changes are taking place, or if they are insufficiently nourished with healthy blood.

A marked feature of inflammatory pain is that it is always aggravated by pressure, whether intrinsic—*i.e.*, by increasing the blood-pressure, as by hanging down an inflamed hand—or extrinsic, from outside agencies, such as mechanical or digital pressure, the pain then being known as tenderness.

The pain of suppuration is throbbing in character; of an inflamed mucous membrane, scalding, burning, or gritty; of an inflamed serous membrane, stabbing; of inflamed bone, aching or boring, and often worse at night; of an inflamed testicle, sickening. When the organs of special sense are inflamed, there may be little real pain, but much exaggeration of the special sense, *e.g.* flashes of light in retinitis and noises in the ears in otitis interna.

The pain is not necessarily limited only to the inflamed part, but is sometimes experienced in distant regions, either through a similarity of nerve-supply or from the fact that a sensory stimulus is always referred by a patient to the end of the affected nerve. For example, in hip disease the chief pain is often felt in the knee, because both joints derive their nervous supply from similar sources. In spinal caries pain is frequently experienced in the terminal branches of the nerves issuing from the part affected, *e.g.* the 'girdle' pain in dorsal disease, and the so-called 'belly-ache' when the dorsi-lumbar region is affected. Occasionally a sympathetic pain is experienced on the opposite side of the body, especially when a bilateral organ such as the kidney is involved.

Inflammation of intra-abdominal organs is often accompanied by pain due to tension of the muscular wall of a hollow viscus which may be definitely local, but is also frequently associated with pain referred to various somatic nerves (viscero-sensory reflexes), and possibly with muscular effects (viscero-motor phenomena). It will suffice here to mention that a renal calculus will produce pain in the groin and front of the thigh (genito-crural area), and perhaps retraction of the testicle; gall-bladder lesions are often productive of pain in the right shoulder. Other illustrations are noted elsewhere.

Impairment or Loss of Function is due sometimes to the mechanical difficulty of using a swollen organ, sometimes to the pain elicited by such attempts, but often to the paralyzing effect of the inflammatory process, and this in infective lesions results from the direct influence of the toxins on the protoplasm of the cells affected. Thus, an inflamed eye is from various causes of little use for vision; a muscle, when inflamed, is naturally kept at rest; glandular organs, *e.g.* the liver and kidneys, have their functions, if not lost, at least much diminished; and many similar illustrations might be added.

Constitutional Symptoms are constantly present in inflammatory conditions, and vary greatly in their severity with the cause. In non-bacterial cases there is usually some slight fever which does not last long; but when bacteria are present, the absorption of toxins may cause general symptoms varying in degree from a mild febrile reaction to a grave toxæmia which causes death. It is, however, remarkable how much disturbance a small collection of pus under tension may sometimes produce.

It is necessary at this place to deal only very briefly with the subject of **Fever** or pyrexia. The general characteristics of the febrile state consist in a greater or less elevation of temperature, accompanied by a corresponding acceleration of the rate of the heart·

beat and of the respirations. If it continues, the patient becomes thin and emaciated, and loses muscular power. The mouth is dry and the tongue furred; and in the later stages the lips and teeth are usually covered with sordes (or accumulations consisting of inspissated mucus and food débris in which bacteria grow and flourish as in a culture-medium). The appetite is impaired, digestion is imperfect, and the bowels constipated; the motions are often very offensive. The urine is scanty and high-coloured, and owing to the excessive tissue metabolism contains an unusual amount of urea and urates. The excess of urea can be demonstrated clinically by adding an equal part of cold nitric acid in a test-tube to some urine, when crystals of nitrate of urea will form on the top of the fluid, giving rise to a mass somewhat resembling sugar-candy in appearance. The skin of a febrile patient is often dry.

The intensity and character of the fever vary with the preceding condition of the patient, and with the nature and duration of the disease. In young healthy adults the fever associated with an acute inflammation is usually of an active type, pyrexia and its accompanying phenomena, including, perhaps, a noisy delirium, being well marked (sthenic inflammatory fever). In debilitated subjects, as also towards the close of a long period of pyrexia (*e.g.*, in the third week of enteric fever), and in grave infections such as erysipelas and septicæmia, exhaustion and collapse manifest themselves (asthenic fever, or the typhoid state). The pyrexia is not necessarily high, and the patient often develops a condition of partial consciousness or low muttering delirium, picking at the bedclothes and passing his excreta in bed.

A **Catarrhal** inflammation is one affecting mucous membranes, which in the early stages become dry, vividly red, and the seat of a burning or scalding pain, whilst in the later stages there is free secretion of mucus, muco-pus, or pus. At first the mucigenous function of the hyperæmic membrane is abrogated, and any extravascular exudate passes into its substance, causing it to become swollen. Cloudy swelling and proliferation of the epithelium soon follow, with increased formation of mucus and partial, or, in severe cases, extensive, desquamation of the epithelial cells, these passing into the exudate as catarrhal cells. As the membrane becomes more and more infiltrated with leucocytes, these are added to the discharge, which is thus transformed into muco-pus, or even almost pure pus, and small ulcers may develop from the loss of superficial epithelium. Microscopical examination of the discharge reveals catarrhal and pus cells. This form of inflammation is caused by bacteria, or by the action of local irritants, and, when occurring in the nose, throat, etc., is what is known as 'catching cold.'

A **Croupous** or **Plastic** inflammation is one characterized by the formation of a firm false-membrane, due to the coagulation of the plasma exuded from the vessels, and the deposit on the surface of the resulting fibrin. When involving a serous surface, such as the pleura, peritoneum, or synovial membrane, it gives rise to a

layer of plastic lymph, which may be absorbed, or organized into adhesions; it is also seen in the alveoli of the lungs in lobar pneumonia. On mucous surfaces it may form a white, or yellowish-white, flaky mass—the so-called 'false membrane'—which can be readily detached, leaving an injected surface beneath, and with no loss of substance, unless superficial necrosis has also occurred in the mucous membrane itself.

The term **Phlegmonous** inflammation is now but rarely employed. It was formerly applied to any inflammation of the subcutaneous or submucous connective tissues of a spreading character, and with a well-marked brawny inflammatory swelling or phlegmon.

Parenchymatous and **Interstitial** inflammations are terms which indicate that in an inflamed organ or gland the process is limited mainly, either to the actual and active substance of the organ, or to the supporting fibrous tissue.

Treatment of Acute Inflammation.

It is possible here to deal only with general principles, the application of which to different parts of the body will be considered later.

I. **The Local Treatment of Non-bacterial Inflammation.**—1. **Remove the exciting cause,** if evident, and any contributory causes when feasible. This is not a difficult matter when the lesion is a gross one and the exciting cause tangible, *e.g.* a foreign body embedded in the conjunctiva or cornea, or the use of a chemical irritant such as formalin in an occupation eczema. In the majority of cases, however, the exciting cause has ceased to act, as in the case of blows, sprains, burns, etc., and all one can do is to protect the part from further irritation or secondary bacterial infection, to relieve tension, and then to assist the tissues towards healthy repair.

2. **Keep the inflamed part at rest.** Wherever inflammation exists, both physical and physiological rest should be secured as far as possible. Thus, an inflamed joint is immobilized; an inflamed breast needs both support and the fixation of the arm, whilst if in a condition of physiological activity this must be checked; an inflamed cornea needs the application of a pad and bandage to prevent the friction of the eyelid; an inflamed retina is put to rest by exclusion of the light.

3. **Reduce the local blood-pressure** and hyperæmia, and thereby relieve tension by diminishing both exudation and pain. It may be pointed out here that, although both hyperæmia and exudation are beneficial, yet they are often present in excess, and it then becomes needful to keep them under control. **Elevation** of an inflamed limb may secure this end, and is usually required in inflammatory conditions of the leg, for it is well known that emptying the veins by gravity leads to reflex contraction of the arteries. This elevation must not be overdone, or serious interference with the vitality of the limb may result. The rule adopted is to raise

the affected part to such an extent as to assist the venous return without interfering with the arterial supply. The employment of a suspensory bandage for an inflamed testicle may be taken as another example of this principle. **Local blood-letting** by punctures, scarification, and wet or dry cupping, is useful in suitable cases, and sometimes gives immediate relief to pain.

Cold wisely utilized is of the greatest service in reducing hyperæmia by causing contraction of the arterioles. It should be used only in the early stages, as it depresses the vitality of the part, and so, if much congestion is present, may do more harm than good. Again, it should be used with the greatest care in old people, from fear of causing necrosis of the skin. Cold may be applied by means of an ice-bag; or by irrigation from a vessel suspended over the part containing iced water or lotion, from which strips of lint descend to envelop the inflamed area; or a piece of lint wrung out of evaporating lotion may be placed directly on the part; or, better still, the iced water may be run through a coil of leaden pipes (known as Leiter's tubes), fitted carefully to the inflamed region.

Heat, especially when combined with moisture, is very largely used in treating inflammatory affections, and acts in a diametrically opposite way to cold by relaxing the vessels and tissues, thus reducing the tension and pain; it also favours the activity and vitality of the part by increasing the vascular supply and facilitating lymphatic absorption. For subcutaneous lesions, rubber hot-water bottles, fomentations, medicated or not with opium or belladonna, or spongiopiline wrung out of hot water, poultices, or simply dry heated cotton-wool, may be employed. Other methods of employing dry heat are suggested in Chapter XI., but are more applicable to the chronic varieties of inflammation.

II. **The Local Treatment of Inflammation of Bacterial Origin.**—This is a somewhat different problem in that its object is to destroy bacteria, to eliminate their toxins, and to attain this end with as little destruction of tissue as possible. The chief difficulty lies in the stagnation present in the bloodvessels and lymphatics of the inflamed part, so that no fresh blood is circulating through it. At the same time the toxins formed by the bacteria have the opportunity of acting on the tissues, and are absorbed into the blood, thereby leading to its deterioration. It is more than doubtful whether antiseptics which do not involve the total destruction of the tissues invaded have any influence on bacteria when once the latter have established their foothold. If applied in weak solutions they are incapable of acting on the bacteria, and if in strong solutions they are liable to add to the damage already inflicted on the parts by the bacteria and to check reparative processes. Hence the agencies at our disposal for combating a bacterial inflammation are: (*a*) The antitoxic and bactericidal properties of the blood, which can be influenced beneficially by antisera, vaccines, drugs, and diet; and (*b*) external applications and procedures, directed towards the removal of stagnant blood and exudate, and to the provision of a

sufficient supply of fresh blood which shall assist the tissues in the direction of repair. The actual methods are as follows:

1. **Remove the cause** if possible, as, for instance, an infected foreign body, or a buried stitch at the bottom of a sinus. In some cases it is possible totally to excise a local focus—*e.g.*, the track of an infected gunshot wound; whilst in others, such as a carbuncle, one can cut or scrape away the greater portion of the infiltrated and sloughy tissue, but this is only of value so long as the infection is limited and localized.

2. **Keep the inflamed part at rest** as far as possible, not only for physical and physiological reasons, but also to prevent mechanical dissemination of the infective virus. This may be effected by confining the patient to bed, or by the use of splints or slings. Special consideration must, however, be given to the later functional effect upon a part of prolonged immobility (p. 299).

3. **Unload the stagnant vessels,** both veins and lymphatics, by elevation, hot applications, which soften and relax the tissues, or by local blood-letting. Scarification is of great value in the slighter cases; but, when stasis has occurred, free incisions are often indicated in order to relieve tension, and also to allow of the escape of bacteria and their toxins.

4. **Promote the removal of the exudate** which is hampering the efforts of the tissues to regain the mastery over the bacteria. (*a*) This exudate may collect in spaces in and amongst the tissues (called by Sir A. Wright ' dead spaces '), or in an abscess cavity with or without contained sloughs or foreign bodies. Free incisions and effective mechanical drainage are required for these, and drainage tubes or gauze packs at a later date. (*b*) The exudate may also be held up in the tissues, and by its pressure on the vessels may prevent the access of fresh blood, the escape of antibacterial lymph, and the emigration of leucocytes. For this condition of the wound, tissue-drainage or lymph-drainage is required, and no means is more effective for this purpose than the constant application of some hypertonic substance, such as salt solution (5 per cent.). The methods of application of this agent and a short note on its physiological action are given at p. 93. (*c*) In the later stages, when there is free discharge of pus, the exudate must be removed by the use of irrigation or baths so as to hinder the erosive or digestive action of the trypsin set free from broken-down leucocytes.

5. **Increase the supply of healthy blood** to the part by the application of heat, as by poultices when the skin is unbroken, or boric acid fomentations if there is a wound, or by employing one of the methods of artificial hyperæmia suggested by Professor Bier.

Artificial or induced hyperæmia as a means of treatment for inflammation is based on the assumption that the hyperæmia and accompanying leucocyte-emigration are useful rather than harmful if they can be suitably controlled. In acute cases the hyperæmia is usually excessive, and therefore harmful by preventing the access of fresh healthy blood to the part. Bier's treatment requires the relief

of this natural harmful congestion by elevation, etc., and subsequently replaces it by a controlled hyperæmia, the parts being flooded from time to time with fresh blood.

Induced hyperæmia is of two types, active and passive. The **active** variety consists in determining an increased flow of blood to the part by vaso-dilation, and is arterial in origin. It is best accomplished by heat, either by fomentations, or immersion in hot water, or by one of the diverse methods of applying hot air now available (*e.g.*, radiant-heat baths, in which the heat may be assisted by various other elements in the spectrum).

Passive hyperæmia is venous in origin, and may be induced by the application of a constricting bandage on the proximal side of the inflamed area, or by the use of Klapp's suction balls. The constricting bandage is of elastic material, and Martin's rubber bandage may be suitably utilized. It is applied with sufficient firmness to obstruct the venous return without interfering with the arterial supply, and if this is satisfactorily effected, the limb becomes reddish-blue,

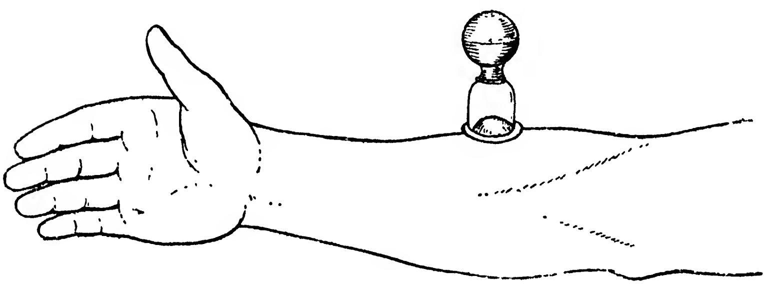

FIG. 14.—KLAPP'S SUCTION BALL.
Suitable for small superficial infections—*e.g.*, boils or carbuncles.

swollen, and œdematous, but without pain; if it becomes cold, or the patient complains of the pain being increased, the bandage has been applied too tightly. By the use of a blood-pressure armlet and gauge, the amount of pressure may be accurately adjusted. When the correct degree of tension has been reached, the limb is comfortable, and the bandage may be retained in position for two or three hours at a stretch twice a day, being removed between the applications so as to relieve the œdema and empty the limb of the accumulated and more or less stagnant blood. This method of treatment is maintained until the inflammation diminishes, and then the length of the daily application of the bandage is gradually reduced.

Klapp's suction balls (Fig. 14) are employed in cases where a rubber bandage cannot be applied—*e.g.*, for an abscess or carbuncle on the trunk or back of the neck, for an inflamed breast, or for a septic finger. A suitably-shaped bell-glass (similar in type to the wet or dry cup of olden days), the edge of which is greased or moistened, is fitted over the inflamed part, and the air within

rarefied by a rubber suction-pump. Blood is thereby drawn into the tissues, which swell up into the cup; and if there is an open wound, as in a boil or carbuncle, discharge and sloughs are sucked out therefrom. The application is maintained for five or ten minutes two or three times a day.

6. **Prevent the access of fresh or a mixed infection** to an open wound by suitable dressings and antiseptics.

III. **General Treatment of Inflammation.**—This varies considerably with the condition of the patient and the severity of the attack.

In robust patients where the blood-pressure is high, the pulse large and full, and the local signs, pain, etc., well marked, it may be advisable to lower the arterial tension by means of such drugs as antimony, aconite, ipecacuanha, acetate of ammonia, colchicum, etc., whilst means are also taken to ensure free activity of the skin, kidney, and bowels, whereby toxins and other irritating substances may be eliminated from the body, and the blood thereby purified. In a few cases—*viz.*, acute pneumonia or meningitis—it may even be desirable to resort in the early stages to venesection, but only in powerful, full-blooded adults, and never to such an extent as unduly to lower their resistance. Subsequently the administration of a suitable supply of simple, easily-digested food is required, the exact nature of which depends on the temperature and the condition of the digestive organs, as indicated by the tongue, etc.

When the patient is weakly and feeble, and especially when his strength has been gradually sapped by persistent fever and toxæmia, general treatment is mainly a matter of feeding, and depends as much on the care and devotion of the nurse as on the skill of the doctor. Stimulants may be required in these cases, and, of course, the functions of the bowels and kidneys must be suitably attended to, though without depressing the patient's strength.

It is probable that moderate pyrexia is useful rather than harmful in infective diseases, in that it encourages the formation of antibodies. Hyperpyrexia, however, is harmful, in that it paralyzes the tissues and checks the production of these substances. It is unnecessary, therefore, to employ antipyretic measures except when the temperature runs high, and the chief reliance should then be placed on drugs such as quinine or aspirin, or on tepid sponging.

Chronic Inflammation.

The **Causes** are similar in character to those producing the acute varieties of inflammation, but slighter and more prolonged in their action. Many of the manifestations met with in surgical practice are due to syphilis, tubercle, gout, or rheumatism, and one should never treat chronic cases without carefully inquiring as to the possible existence of some such underlying disease.

The **Phenomena** are essentially the same as those of the acute process, though the development is somewhat different.

1. The hyperæmia is less in degree, but longer in duration, owing

to the causative irritant being frequently of moderate or slight activity. The local manifestations, therefore, are less obvious; pain is not so great and mainly of an aching character, whilst there is less heat, the redness is more dusky, and the tissues often become pigmented. Considerable loss of tone in the vessels, especially the veins, results from their prolonged distension, and thus there is greater difficulty in restoring them to a normal state.

2. The corpuscles do not adhere together or run into rouleaux to the same extent as in acute inflammation, and migration of polymorphs, though it exists, is on a limited scale. The exudate is more fluid in character, containing comparatively little albumin or fibrin; in fact, in some chronic inflammations of serous membranes the cavities are distended with fluid of a much lower specific gravity than that of blood-serum.

3. The greatest difference between the acute and chronic processes lies in the reaction of the tissues. In acute inflammation, increased proliferation of the tissues is rarely a marked feature; in chronic inflammation overgrowth of the tissues, especially those which are less specialized in their functions, *e.g.* the connective tissues, is of constant occurrence.

An area which is in a state of chronic inflammation is infiltrated with **round cells** which are derived from various sources. (*a*) In certain tissues, cell-proliferation is well marked, especially in the **endothelial cells** of the vessels, perivascular lymphatics, and lymph-clefts, whilst in other parts, *e.g.* the central nervous system, the nerve-cells themselves, though the neuroglia cells do so in varying degree, never undergo proliferation. (*b*) In most cases, however, these round cells are indistinguishable from **lymphocytes,** and are often found grouped in large numbers round the smaller vessels; in the chronic granulomata this is specially characteristic, large areas composed mostly of these lymphocyte-like cells being present. (*c*) Another cell which is often found in these lesions is the **plasma-cell;** it is larger than the lymphocyte, and usually of an oval shape; the nucleus is about as large as that of a lymphocyte, is rich in chromatin, peripherally arranged in large granules, and is placed eccentrically in the cell. The protoplasm has peculiar staining affinities. These cells may occur in chronic inflammatory lesions in great numbers, sometimes almost to the exclusion of other types in areas of considerable size; but generally they are mixed with lymphocytes, etc.

From whatever source they are derived, these newly-formed cells usually develop into fibrous tissue, but sometimes produce structures more or less resembling normal tissue. Organization is therefore a marked feature of chronic inflammation. The actual **results** vary according to the part of the body affected, and also with the cause of the trouble. In **simple** chronic inflammation, not due to tubercle or syphilis, the part becomes infiltrated and enlarged, and if this persists, fibrosis or sclerosis follows. Thus, a bone is thickened and condensed in chronic osteitis (osteo-sclerosis), and in chronic

periostitis a new subperiosteal formation of bone occurs. Lymphatic glands become enlarged and indurated, mainly by hyperplasia of the adenoid reticulum and connective tissue; if the skin is involved, it either becomes hypertrophied and thickened, or entirely loses its characteristic structure, being converted into granulation or fibro-cicatricial tissue, with or without an intervening ulcerative stage. True suppuration rarely occurs, although certain organisms of low virulence occasionally lead to its development. Tuberculous and syphilitic lesions have their own characteristic features (*q.v.*).

Constitutional symptoms are but little evident, beyond those dependent on the condition to which the local phenomena are due, or to septic changes developed secondarily.

The **Treatment** of chronic inflammation is usually more prolonged and difficult than that of acute cases.

1. The cause must be removed whenever practicable, *e.g.* foreign bodies, dead or diseased bone, septic teeth or tonsils, etc., require removal; or a chronic abscess must be aspirated, or if need be opened and drained.

2. Keep the part at rest. This is just as much an essential as in the treatment of acute inflammation. Affected joints should be immobilized; the spine must have the weight taken from it by suitable appliances, or, better still, by maintaining the recumbent position; secretory glands are not actively exercised, and the organs of sense are protected from irritation.

3. Counter-irritation is one of the most useful forms of treatment for chronic inflammatory conditions. It is applied in many different ways, according to the character of the disease and the part involved. Thus, friction with the hand, or with stimulating embrocations, produces a hyperæmic condition of the skin, and promotes local activity in the superficial parts which may react beneficially on deeper structures. Scott's dressing may be similarly employed; it consists in wrapping up the part (*e.g.* a joint) in strips of lint covered with ung. hydrarg. co. (containing over 10 per cent. of camphor), and then encircling it firmly with soap plaster, spread preferably on chamois leather. Iodine paint is another useful application, whilst blisters are most valuable in suitable cases; they are produced by applying a cantharides plaster, or by painting the affected area with liquor epispasticus or a collodion blistering fluid. The actual cautery is the most severe form of counter-irritant, and is especially useful in some varieties of chronic inflammation of bones and joints. The exact *modus operandi* of counter-irritants is a little difficult to understand, but it seems likely that in some cases they act by determining hyperæmia of the part, and in others through some influence on the nervous supply.

4. Pressure is an important element in the treatment of chronic inflammatory disorders, and probably acts by bracing up vessels which have become relaxed and atonic from the prolonged distension to which they have been subjected. It also favours the absorption of inflammatory exudates. Firm bandaging, and

especially the use of an elastic support, are the usual methods of application.

5. Artificial hyperæmia (Bier's treatment) is also of value in chronic inflammation, and perhaps finds most useful expression in the form of hot-air baths, or varous electrical methods noted elsewhere (Chapter XI.), or in the direction of massage and remedial exercises.

6. General or constitutional treatment must be adopted to meet the specific diseases which are commonly associated with chronic inflammation, *e.g.* mercury or iodide of potash in syphilis.

7. Finally, if the condition is bacterial in origin, and the organism can be isolated, a vaccine may be prepared and treatment carried out on the lines laid down on p. 23. Ordinary surgical methods must at the same time, however, not be neglected.

CHAPTER III.

THE BLOOD IN HEALTH AND DISEASE.

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ALTHOUGH an examination of the condition of the blood is frequently of great importance to the surgeon, a mere outline of the chief facts is all that can here be attempted.

Red Blood-Corpuscles.—In health, these vary between 5 and 6 millions per cubic millimetre in men—usually $5\frac{1}{2}$ to 6 million in the healthy young adult male—and 5 to $5\frac{1}{2}$ million in women, and are readily counted by means of the Thoma-Zeiss hæmocytometer or other similar instrument. The chief surgical value of such investigations arises in connection with hæmorrhage, for they enable us to ascertain the effect of such loss on the constitution of the blood, and to trace the process of recovery. It is usually advisable to supplement the counting of the corpuscles by estimating the amount of hæmoglobin present by means of Haldane's or some other hæmoglobinometer, the result being expressed as a percentage of the normal amount. Thus, blood containing half the amount that should exist in a given bulk in a normal man is said to contain 50 per cent. of hæmoglobin. It is also convenient to calculate the 'corpuscular richness' or 'colour-index,' which is done by dividing the percentage of hæmoglobin by the number of corpuscles expressed as a percentage of the normal. For example, if under normal conditions the hæmoglobin is 100 per cent., and there are 5,000,000* corpuscles per cubic millimetre, the colour-index is $\frac{100}{100}=1$. If the corpuscles have fallen to 3,000,000 (60 per cent. of the normal), whilst the hæmoglobin has fallen to 30 per cent., the colour-index is $\frac{30}{60}=0{\cdot}5$; that is to say, each red corpuscle contains only half as much hæmoglobin as it should.

* It has been customary in the past to regard 5,000,000 as the 'normal' number of red corpuscles, and to calculate the colour-index from this figure. As, however, 5,000,000 is, in robust health, an underestimate, it follows that the normal colour-index is often slightly *below* unity when so calculated. A convenient and rapid method of calculating the colour-index is to double the first two figures of the number of the red corpuscles and divide the hæmoglobin percentage by the result. Thus, with the figures 5,000,000 and 100 per cent. $\frac{100}{50\times 2}=\frac{100}{100}=$unity—the present 'standard' figure. But, with 5,500,000 and 100 per cent., the colour-index would be $\frac{100}{55\times 2}=\frac{100}{110}$, or just a trifle more than 0·9. The example given above in the text would give $\frac{30}{30\times 2}=\frac{30}{60}=0{\cdot}5$.

In general, in cases of anæmia, a high colour-index is indicative of pernicious anæmia (*e.g.* 1·0 to 1·2, 1·3 or more); and one which is reduced suggests secondary anæmia (*e.g.* down to 0·7, 0·6, or 0·5).

If the blood is examined immediately after a patient has suffered from a severe hæmorrhage, it will naturally be found to be normal in composition; part has been lost, but the quality of the remainder has not altered. After a short time the volume of blood is restored to normal by means of fluid absorbed from the tissues. In this stage the blood is more diluted than normal, the red corpuscles and hæmoglobin being alike reduced, the latter more than the former. There is also in most cases a temporary increase in the number of leucocytes. The process of absorption of fluid from the tissues is imitated artificially in the infusion of saline solutions in collapse or after severe hæmorrhage, and it is found that this process has a beneficial effect in accelerating the subsequent regeneration of the blood as well as in raising the blood-pressure and removing the urgent symptoms.

In the subsequent process of recovery the red corpuscles increase more rapidly than the hæmoglobin, so that the colour-index falls somewhat. The length of time necessary for full regeneration of the blood varies greatly, the process being more rapid in men than in women, and in young adults than in the old or in children. Approximately 1 per cent. of hæmoglobin is regenerated *per diem*; thus the blood should become normal in about twenty days after the loss of 20 per cent. of hæmoglobin if the patient is kept under favourable conditions.

It is not possible to lay down any definite rule as to the amount of hæmorrhage which is necessarily fatal. Other things being equal, a patient will survive a much greater loss of blood if it takes place gradually than if it takes place quickly. In the latter case a reduction of the hæmoglobin to 50 per cent. will probably be fatal, whereas in the former it may fall to 20 per cent., or lower, and recovery still take place. Women tolerate loss of blood better than men, and men tolerate it better than children.

Anæmic patients are usually bad subjects for operation, but it is not possible to formulate any precise rule for the guidance of the surgeon as to the degree of anæmia which should make him unwilling to operate. Whenever the operation is likely to be of a serious nature, preparatory blood-transfusion should be considered.

It is important to notice that a high degree of anæmia occurs in acute streptococcal lesions, septicæmia, etc., and this fact is occasionally of diagnostic value. The diminution of the corpuscles and hæmoglobin usually occurs rapidly, sometimes with a rapidity only second to that which obtains after serious hæmorrhage, and gives rise to a severe form of secondary anæmia. The colour-index is usually low, the hæmoglobin being destroyed more rapidly than the corpuscles.

Leucocytes.—The examination of the leucocytes is often of great importance. It comprises an enumeration of the total number per cubic millimetre, and a differential count of the relative number of the various kinds. The former examination is carried out by a method similar to that used in counting the red corpuscles, and, as it takes but a few minutes and requires but little practice, should be learnt by all surgeons.

The differential count is made on thin films of blood, which are dried and stained by a double or triple stain, of which Leishman's is the most satisfactory. It consists of a solution of eosinate of methylene blue in methyl alcohol. The blood-film, prepared on a clean slide, is allowed to dry spontaneously, and is covered with the stain without preliminary fixation. After one minute the stain is diluted by the addition of double its volume of distilled water, and the diluted stain is allowed to act for five minutes. It is then well washed with distilled water, the excess of water blotted off, and the film thoroughly dried by waving in air. It may then be examined at once under an oil immersion, or mounted in Canada balsam, and examined under a $\frac{1}{6}$-inch lens, each leucocyte seen being noted down until 250 or more have been counted. The results are reduced to percentages.

In health the blood contains about 8,000 leucocytes per cubic millimetre, five different forms of cell being present—the polymorphonuclear leucocyte, the eosinophile, the basophile, the lymphocyte, and the large hyaline mononuclear. Of these, the first three contain numerous definite granules in their protoplasm. In the following description we assume that the film has been stained by Leishman's method. If other staining processes are used, the colours of the various structures will naturally be somewhat different.

1. The **polymorphonuclear leucocyte** (Plate IV., Figs. 5 and 6) is rather larger than a red corpuscle. It is characterized by having a lobed or indented nucleus, which may appear to be multiple, but if carefully examined connecting filaments between the various lobes can always be made out. It contains in its cytoplasm numerous minute granules which stain purplish or pink with Leishman's stain.

The polymorphonuclear leucocytes are the chief phagocytic cells of the blood, being actively amœboid and endowed with the power of ingesting bacteria or other small objects. They are formed in the bone-marrow, and constitute in health from 60 to 75 per cent. of all the leucocytes.

2. The **eosinophile leucocytes** are about as large as the foregoing, and have a bilobed or polymorphous nucleus. Their cytoplasm is packed with coarse granules which stain pink with Leishman's stain.

The eosinophiles form 1 to $1\frac{1}{2}$ or 2, sometimes 3, but certainly not more than 4 per cent. of the leucocytes of normal blood. They also are probably mostly derived from the bone-marrow; they are feebly motile, and their functions are not definitely known.

3. The **basophiles** (or **mast-cells**) have lobed, pale-staining nuclei and a hyaline cytoplasm in which are imbedded a number of granules

staining blue-black with Leishman's stain. They are present in very small proportions (less than ½ per cent.) in normal blood, nor are they ever increased in any pathological condition except myelogenous leukæmia, in which they may share in the increase shown by the other cells arising from the bone-marrow. Their function is quite unknown.

4. The **lymphocytes** (Plate IV., Figs. 5 and 6) contain azurophil granules, which are much less numerous and more scattered than the granules of the three foregoing types of leucocyte; and their nuclei are not polymorphous. They vary in size, but the majority are rather smaller than the red corpuscles. The small lymphocyte has a single circular or slightly indented nucleus which is situated centrally and which stains very deeply; this is surrounded by a narrow zone of protoplasm, which stains a blue colour. The larger lymphocytes have more abundant protoplasm, and are probably younger, *i.e.* less mature, cells of the same series, all intermediate sizes between the two varieties being found.

Lymphocytes constitute some 20 to 25 per cent. of the leucocytes in health. In children the proportion may be much higher, the polymorphs being correspondingly reduced. They are formed in the lymphatic glands, spleen, Peyer's patches, and lymph-adenoid tissue generally. They are usually present in large numbers in chronic inflammatory lesions, but their function is unknown; they are sluggishly amœboid, but appear to have no power of phagocytosis.

5. The **large hyaline mononuclear cells** vary in size, but as a rule are decidedly larger than the red corpuscles. In dried films, they have a single circular, oval, or indented nucleus, which is smaller relatively to the cell than the nucleus of the lymphocyte, and stains much less intensely, so that a reticular structure can be made out. The protoplasm stains a pale purplish-blue. It is devoid of granules, but often shows bluish points, which are really nodal thickenings of the reticulum. These cells form 1 to 3 per cent. of the leucocytes of normal blood, and have considerable powers of phagocytosis, being concerned especially in the ingestion of degenerated or dead cells, parasitic cells, pigment, and remains of tissue, and also—but to a lesser degree than the polymorphs—in the phagocytosis of bacteria. They are actively amœboid, and when watched on the warm stage, not only the cell-body, but the nucleus itself may be seen actively changing its contour and position in the cell. They are probably endothelial cells which have become detached from any of the positions where endothelial cells may be found—the walls of blood-vessels, lymph channels and spaces, serous membranes, and the reticulo-endothelial system generally.

An increase of the total leucocytes present in the blood is termed **leucocytosis.** Under most circumstances this mainly affects the polymorphonuclears, but sometimes there is an increase of the eosinophiles, called **eosinophilia,** or of the lymphocytes, termed **lymphocytosis.** A diminution of the leucocytes is termed **leucopenia.**

Leucocytosis occurs under **physiological** conditions during digestion, during pregnancy, and in the new-born infant. This has to be remembered in interpreting leucocyte-counts in disease; and, in order to avoid misleading results, the blood should when possible be collected whilst the patient is fasting.

Pathological leucocytosis occurs in many conditions, for example after severe hæmorrhage, and in cachectic conditions, especially in that due to malignant disease. In these cases it is almost always due to a local inflammation excited by the new growth, and is rarely of diagnostic value. More important is its occurrence in the majority of the infective diseases, and in these the highest counts are met with in **pneumonia** and in **suppuration.** Its occurrence in the latter is of special importance to the surgeon, as the presence of a high leucocytosis may be regarded as the most definite single sign of the presence of pus. It is especially valuable in **appendicitis,** where the other evidences of suppuration are often equivocal. When no pus is present, the blood shows slight leucocytosis, the number not usually exceeding 15,000 per cubic millimetre. When pus is present the number is much greater, being usually not less than 18,000, and it may rise as high as 50,000 or even higher. For practical purposes a count of 20,000 leucocytes per cubic millimetre may be taken as an almost certain proof of suppuration, presuming, of course, that the other causes of leucocytosis can be excluded. Figures between 15,000 and 20,000 may not be absolutely conclusive of the presence of suppuration, and where they are obtained it is advisable to repeat the examination in twenty-four hours or less. If suppuration is taking place, the count will almost certainly rise, whilst if it remains at the same level, or shows a decline, the presence of pus is less likely. The height of the leucocytosis gives no indication of the size of the abscess or of the rapidity of its spread.

The opening of the abscess is usually followed by a fall in the number of leucocytes, and this is so rapid as to be quite definite in the course of twelve hours. When it does not take place, the probability is that a second abscess is present, which was overlooked at the time of the operation.

Aleucocytosis and Leucopenia.—The absence of leucocytosis is presumptive evidence that suppuration has not occurred, but several facts have to be considered in applying this rule in actual practice:

1. The cause of the leucocytosis is the passage of the bacterial products from the inflammatory focus to the blood-stream, where they exert a positively chemiotactic action, attracting the leucocytes from the bone-marrow, whilst at the same time they stimulate the latter to an increased production of leucocytes. As long as the abscess remains unopened and is spreading, these substances gain access to the blood-stream with ease, for it is the only path available to them. But when the abscess is opened so that the pus laden with bacterial toxins can drain away, the leucocytosis falls, even although the abscess may burrow for a time.

2. When the pyogenic bacteria have been killed, the toxins are soon carried away in the blood-stream and eliminated from the body, and when this has happened the leucocytosis falls, although there is still a collection of pus in the tissues. In other words, a high leucocytosis is to be regarded as a proof of the active process of suppuration rather than as a proof of the presence of pus. For example, sterile collections of unabsorbed pus often occur in cases of pyosalpinx of some standing, and are unaccompanied by leucocytosis, although acute suppuration in the Fallopian tubes causes the usual reaction.

3. When the organisms are very virulent and the patient of feeble constitution, so that the infection rapidly spreads, there is occasionally a failure of leucocytosis or even a leucopenia. This is notably so in severe cases of diffuse septic peritonitis. The general leucocytosis (as well as the local emigration of leucocytes) must be regarded as a conservative and defensive reaction, and indicates that the patient has sufficient resisting powers to combat the infection, or at least to limit it for a time; its absence in a case where there is suppuration renders the prognosis unusually bad.

4. Leucocytosis does not occur in cases of chronic tuberculous or cold abscess. The products formed by the bacteria which produce these lesions have no positive chemiotactic action on the polymorph leucocytes. The cells found in the local lesions are mostly lymphocytes. Hence, even when the toxins of these organisms enter the blood, they fail to attract the polymorph leucocytes from the marrow. We might reasonably expect that an increase in the lymphocytes would occur; but these cells are not actively motile like the polymorphs, and do not so readily respond to chemiotactic influences.

Pre-existing and coincident disease and degeneration of the bone-marrow, due especially to syphilis and chronic alcoholism, may lessen or prevent the necessary leucoblastic reaction, and the occurrence of leucocytosis. The usually rapidly fatal pneumonia with leucopenia, not infrequently seen in alcoholic subjects, can thus be explained.

The relations of some of the other infective diseases to the leucocytes may be briefly epitomized. In erysipelas, diphtheria, scarlet fever, and plague there is a high leucocytosis, the number rarely falling below 20,000. In rheumatic fever (uncomplicated), syphilis, and gonorrhœa there is usually a slight rise; in tuberculosis, typhoid and the paratyphoid fevers, uncomplicated influenza, measles, mumps, and malaria there is usually no excess, and often a diminution, in the number of leucocytes, as also in 'glandular fever,' whooping cough, and small-pox, which are, however, characterized by the occurrence of a lymphocytosis.

Lymphocytosis, or an increase of the lymphocytes, may be absolute or relative. A relative increase (*i.e.* such that the percentage of these cells in the adult rises above 35, although the total number of the leucocytes does not exceed the normal) occurs in

tuberculosis and the other diseases mentioned above as giving no leucocytosis. A great excess of 'lymphocytes' (100,000 to 260,000 or even more per cubic millimetre) occurs in lymphatic leukæmia,* and constitutes an important means of diagnosis between this condition and Hodgkin's disease, in which the leucocytes are normal or but slightly increased. Children's blood contains a larger proportion of lymphocytes than that of the adult, *e.g.* about 60 per cent. until about the fourth year, after which the lymphocytes gradually diminish in numbers, reaching adult proportions about the twelfth year; and in inflammatory diseases of children the increase in the total leucocytes may be due partly to an excess of lymphocytes, and not only of the polymorphs, as in the adult. This is especially the case if the lymph-glands are involved in the inflammatory process.

Eosinophilia, *i.e.* a relative increase of the eosinophiles, occurs in several conditions, most of which appear to be due to the action of some 'foreign' protein: (1) In infection with various animal parasites, *e.g.* in the intestine or elsewhere, and especially in trichiniasis, where the proportion may be 60 per cent. or more. They are sometimes increased in hydatid disease; in doubtful cases this fact has some diagnostic value, but a count in which there is no increase is of little importance. (2) In some skin-diseases, especially when a large area of skin is involved; (3) in anaphylactic conditions, including serum-disease and asthma; (4) in some cases of Hodgkin's disease; and (5) in myelogenous leukæmia. In many infective and inflammatory conditions, on the other hand, they may be diminished in, or even absent from, the peripheral circulation, though they may often in such cases accumulate in and around the local lesions in large numbers.

Blood-Platelets.—These are minute bodies about 2 to 3 μ in diameter, and staining purplish with Leishman's stain. They are formed in the bone-marrow, and are normally present to the extent of 200,000 to 300,000 per c.mm. They show a very great tendency to agglutinate in clumps as soon as the blood leaves the vessels. They are concerned in the process of clotting and thrombosis, and are found in very much diminished numbers (thrombocytopenia) in hæmophilia, scurvy, and some forms of purpura, and in pernicious anæmia.

The Examination of the Blood for Parasites (including bacteria) is often necessary. It may be carried out by microscopical examinations of fresh blood or blood-films, or by cultures; the method to be selected must depend upon the organism sought.

The diagnosis of malaria is effected by examining a wet film of fresh blood in a vaselin-ring preparation, or by the examination of dried films stained by Leishman's method. For descriptions of these and other protozoal parasites and their life-history the reader is referred to special treatises.

* For the discussion of the nature of the cells in lymphatic leukæmia, see textbooks of Pathology and Hæmatology.

Relapsing fever is due to a corkscrew-like organism (*Treponema* or *Spirochæta obermeieri*—or *Borrelia recurrentis*—or *Spirillum obermeieri*), which is about two or three times as long as the diameter of a red corpuscle. It may be demonstrated by the methods used for the malaria parasite, and in fresh specimens is as a rule actively motile.

The diagnosis of filariasis is best made by examining with a low-power lens thick layers of fresh blood taken at night, if *F. nocturna* is suspected; in the daytime, in the case of *F. diurna*; and at any time if *F. perstans* is sought.

For the demonstration of **bacteria** in the blood, **cultural** methods are almost always necessary, for their numbers are usually so small that the chance of finding even a single organism in a stained blood-film is remote. After thorough sterilization of the skin, preferably with 1 : 500 biniodide spirit, the blood must be withdrawn directly from a vein, either with a sterile syringe, or run through a puncture-needle and a short length of narrow rubber tubing, into flasks or bottles containing several hundred c.c. of suitable nutrient broth. At least 5 or 10 c.c. of blood should be so added to the culture-medium at the bedside, immediate dilution with a sufficient quantity of the nutrient fluid being essential to success. The flasks are placed in the incubator after inoculation and subcultures made from them at intervals upon a series of suitable media, and both these and the primary cultures examined daily up to at least five days. It is worse than useless to attempt to make a bacteriological examination of blood obtained from a skin puncture, however carefully the skin may have been sterilized; or from blood which has been allowed to clot or which has been kept any length of time before addition to the culture fluid.

In septicæmia, pyæmia, ulcerative endocarditis, and other diseases due to bacteria, the organisms may be present only intermittently in the blood, and so may or may not be successfully grown from such cases. A positive result is most likely to be obtained in severe cases, especially when the blood is collected during a rigor. It is of serious import, although such cases are by no means necessarily fatal. Cultures in which staphylococci are the only organisms to develop must be interpreted with caution, as being possibly due to accidental contamination. A single negative result is usually of little value in diagnosis, and the cultural examination may require to be repeated several times.

Blood-culture is a most valuable means of diagnosis of typhoid and paratyphoid fevers, in which the organisms can nearly always be isolated from the blood during the first week of the disease. They usually disappear from the blood during the second week, when, however, the agglutination reaction (p. 19) may become positive.

Transfusion of Blood.

Transfusion of blood has often been adopted in the past, but with so little success and with so many mishaps that it was laid aside in favour of infusion of saline solution. It is not to be wondered at that, in the absence of tests as to compatibility, failure and disaster frequently followed. The modern methods of blood grouping and matching have, however, now rendered transfusion comparatively safe.

In cases of serious hæmorrhage, transfusion may be employed with great benefit, as also in grave shock, but in the latter condition the problem as to whether blood or a solution of gum is the better has not yet been definitely settled (p. 283). Transfusion is also valuable in chronic conditions where much destruction of blood has taken place, *e.g.* in septic lesions with severe secondary anæmia, in pernicious anæmia, and in certain diseases of the spleen. In some cases it is desirable to treat the patient for some time previously by repeated transfusion of blood before attempting serious operations.

The chief causes of failure in the past lay in the non-recognition of the fact that the blood of one individual may be incompatible with that of another, and before transfusion is undertaken careful tests must be made to determine this point. The incompatibility may arise in two directions: (1) the red corpuscles of the donor may be agglutinated by substances in the plasma of the recipient; and (2) such agglutination may or may not be followed by active hæmolysis, the corpuscles being dissolved with a resultant hæmoglobinuria. Hæmolysis is always preceded by agglutination, but does not invariably follow the injection of an incompatible blood; the result depends on the degree of incompatibility. It is only necessary, therefore, to test whether agglutination occurs when the donor's corpuscles are brought into contact with the recipient's plasma.

It has been found that all individuals fall into four main groups* as regards agglutination and hæmolysis; this is shown in the table given on p. 55. It is probable that there may be sub-groups of these, and further research is still required upon this important subject—as occasional accidents have occurred even when the donor's group appeared to be suitable. The sera used for the grouping must be tested from time to time to prove that they are still active.

It will be seen from the table that individuals in Group I. can receive blood from any other group, and so may be looked on as universal recipients, whereas individuals in Group IV. are to be looked on as universal donors causing no agglutination with recipients of any other class, but they can only receive blood safely from members of their own class. Donors of Group II. can only

* For a discussion of these and a proposed simplification of the terminology, see two papers by S. C. Dyke, 'The Significance of Blood Groups,' *Lancet*, May 3, 1930, p. 977, and May 10, 1930, p. 1029

give blood safely to individuals in Groups I. and II.; and those of Group III. to recipients of Groups I. and III. It has been shown that the plasma of the donor has generally no appreciable effect upon the cells of the recipient. This has been ascribed (*a*) to rapid dilution of the plasma of the donor in the vessels of the recipient, or (*b*) to the presence of protective or anti-hæmolytic properties in the recipient's plasma.

Serum of Recipient.	Cells of Donor.				*No. of Individuals in Group.*
	Group I.	*Group II.*	*Group III.*	*Group IV.*	
Group I.	O	O	O	O	I. =5 per cent.
Group II.	×	O	×	O	II. =41 ,,
Group III.	×	×	O	O	III. =12 ,,
Group IV.	×	×	×	O	IV. =42 ,,

O=No agglutination. × =Agglutination.

The method of **testing blood** is simple. All that is necessary is to secure known sera of Groups II. and III., which are obtained with aseptic precautions and preserved by adding 1 per cent. of chloroform in small drop bottles, or in sealed capillary tubes. A drop of each is then placed at one end of a clean microscope slide, and a small drop of blood is obtained from the person to be tested. This is mixed well with each drop of serum, and in a few moments clumping of the corpuscles, if it occurs, is rapidly visible and soon becomes well marked. Hæmolysis need not be specially tested for, as where there is no agglutination it does not occur.

Even when stock typing sera are available, and the grouping of donor's and patient's bloods apparently suitable, the patient's serum and the blood of the prospective donor should always be directly tested. A few cubic centimetres of blood from the patient's ear or finger are collected and allowed to clot. A sufficient amount of serum will be available at the end of ten or fifteen minutes. (Citrated or oxalated plasma may be prepared if desired; such plasma is equally efficient.) The test is then executed as above indicated. Absence of agglutination indicates compatibility. In hospitals where this procedure is likely to be required at all frequently, it is wise to have certain individuals who may act as donors tested, and their groups determined. A member of Group IV. is, of course, always suitable as a donor. No transfusion should ever be undertaken without the preliminary tests.

Methods of Transfusion.—The success of this procedure depends not only on the right selection of cases for its employment and of suitable donors, but also on the technique adopted so as to ensure

that no harmful admixture of air or of clot shall be introduced into the recipient's vessels; it is also desirable that the vessels shall not be harmed, so that if need be they can be employed again, and that no unpleasant after-effects shall be produced. Many differing types of procedure have been from time to time utilized, and the fact that still others are being suggested proves that the final 'best' is still to be found. The following are some of those hitherto employed:

(1) **Direct transfusion** (artery to vein transfusion) has been used with success, but inasmuch as it involves an operation of some gravity on both patients, and there are no means of estimating the exact amount of blood transferred, and that both vessels have to be ligatured, it is not to be recommended.

(2) **Kimpton's tube** (Fig. 15) was the apparatus most frequently used at first. The interior of this is carefully and completely

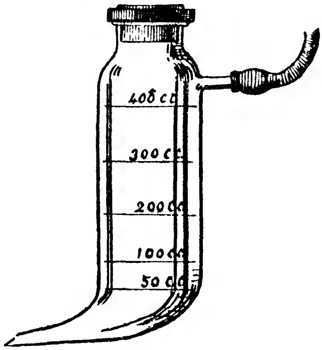


FIG. 15.—KIMPTON'S TUBE FOR BLOOD TRANSFUSION.

coated with paraffin wax. The arms of the patient and donor are prepared, and suitable veins are exposed. The open end of the Kimpton bottle is inserted into the distal portion of the donor's vein, and 400 to 450 c.c. of blood are withdrawn. Without delay the open end is then introduced into the patient's vein, and the transfusion completed with the aid of positive pressure made through the upper side tube. The great drawback is the risk of clotting in the cannula or at the bottom of the tube, so that the method is never absolutely certain of success even in the hands of an expert; moreover, both the vessels employed have to be ligatured.

(3) The technique now much employed is that known as the **Citrate Method,** and it is one of the best and simplest. The apparatus known as Robertson's bottle or flask (Keynes' modification*), which can easily be fitted up in any laboratory, is used; 2 grammes of sodium citrate are dissolved in 100 c.c. of recently distilled water, and placed in the 1,000 c.c. flask (Fig. 16), the neck of which is

* 'Blood Transfusion,' by G. Keynes. Henry Frowde, London, 1922.

plugged with cotton-wool. The side-arm of the flask is protected by a little glass bulb containing cotton-wool, and to it a short length of rubber tubing is affixed; the whole is sterilized in an autoclave.

After the preparation of the skin of the donor, a tourniquet is applied above the elbow so as to impede the venous return without interfering with the arterial supply; a blood-pressure apparatus serves admirably for this. A few minims of novocain solution (2 per cent.) may be introduced over the selected vein, and a small incision made through the skin. A large bore needle previously sterilized in a long test-tube plugged with cotton-wool (Fig. 16) is then inserted into the vein, and the blood allowed to flow through rubber tubing into the flask. An assistant carefully and thoroughly mixes the blood with the citrate solution by agita-

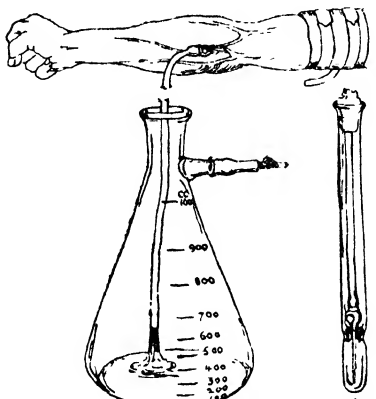


FIG. 16.—ROBERTSON'S FLASK ARRANGED FOR RECEIVING BLOOD FROM DONOR.

For clearness the citrate solution has not been represented. A shows test-tube employed for sterilizing the needle.

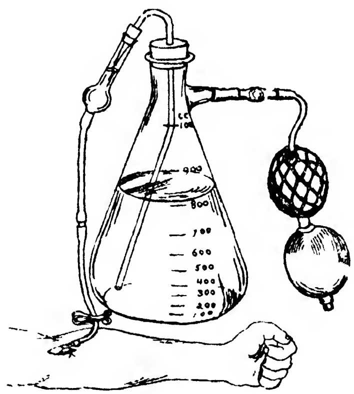


FIG. 17.—ARRANGEMENT OF ROBERTSON'S FLASK FOR ADMINISTERING MIXTURE OF BLOOD AND CITRATE SOLUTION.

tion, whilst the operator controls the needle in the vein. If only 200 or 300 c.c. of blood are required, a direct puncture through the skin into the vein suffices, using a needle of 1 millimetre bore; in cases of difficulty the vein must be completely exposed, and a cannula employed.

The blood thus obtained and mixed with the citrate solution may be kept, if desired, for several hours before injection, and introduced into the circulation of the recipient when convenient. A delivery tube (Fig. 17) is prepared, passing through a rubber cork carefully fitted to the open end of the flask: also an air-lock or calcium chloride tube of greater internal capacity than the delivery tube: and a needle or cannula with a suitable length of rubber tubing; these are all previously wrapped in lint and sterilized. The needle

or cannula is connected by the rubber tubing with the barrel of the air-lock; the whole is filled with sterile warm saline solution, so as to displace all air, and the needle or cannula is then inserted into a suitable vein with the usual aseptic precautions. As soon as it is seen that the saline is flowing freely the tube is pinched, the barrel of the air-lock is again filled with saline, and it is attached to the delivery tube, which has been placed in the flask, to the side-arm of which is attached a rubber blowing-ball (Fig. 17). The clip or constriction is then removed from the rubber tubing, and by compression of the blowing-ball the citrated blood is forced over into the vein of the recipient. Inasmuch as the capacity of the delivery tube is less than that of the air-lock, there is no risk of the air contained in the delivery tube being forced into the vein. Anything up to 1,000 c.c. of blood can easily be given by this method; the maximum amount usually introduced at one time is 700 to 800 c.c. When smaller amounts are required, the quantity of citrate can be correspondingly reduced.

(4) Keynes' method has been still further modified by P. C. Gibson,* the citrate solution being added gradually from another flask as the blood is withdrawn and meeting it in the tubing close to the needle in the donor's vein, the withdrawal being facilitated by negative pressure in the reception-flask produced by an air-pump.

(5) In actual practice it has been found that in many cases unpleasant after-effects, such as fever, rigors, and malaise, have been experienced when the citrate method is employed, and these are, it is alleged, due to the presence of the citrate. To obviate this, and yet to be able to retain the advantage of the citrate method in not having to employ the blood immediately, but after the delay of a few hours, if desirable, the plan of employing **defibrinated** blood has been recommended and has proved of real worth.† The blood is withdrawn from a vein through a cannula and tube and collected in a jar, in which, by constant shaking so as to swish the blood around a glass rod incorporated in the apparatus, both during the removal and for some six minutes after, the whole of the fibrin can be removed as a clot upon the rod, and that without entangling the red cells which it is so desirable to transfer to the recipient. The blood, thus defibrinated, is either immediately, or after an interval of a few hours, injected into the recipient's vein through a glass tube, with a small glass-wool filter interposed so as to catch any stray fragment of fibrin that may be present. A syringe with a two-way tap is employed for this purpose. It is claimed that an entire freedom from unpleasant after-phenomena is secured by this means.

(6) It is possible that the employment of the two-way syringe

* 'The Technique of Blood Transfusion,' by Paul C. Gibson, *Lancet*, August 21, 1926, p. 375.

† See Colebrook and Storer, 'On Immuno-transfusion,' *Lancet*, December 29, 1923.

referred to above, as originally recommended by Joubet,* may prove to be the most desirable method of transfusion; attached to either side of the syringe by rubber tubes are two needles which are inserted respectively into the veins of donor and recipient. The syringe sucks up blood from the donor, and by turning the grooved piston round to a second position, the down-stroke of the syringe drives it directly into the vein of the recipient, and this act is repeated as often as is necessary. The reports given of this procedure are very satisfactory.

* See 'A Simplified Method of Arm-to-Arm Blood Transfusion,' by E. F. Skinner, *Brit. Med. Jour.*, March 24, 1928, p. 492.

CHAPTER IV.

NON-SPECIFIC* PYOGENIC INFECTIONS AND INFECTED WOUNDS.

REVISED BY W. E. CARNEGIE DICKSON, M.D., B.Sc., F.R.C.P.E

IN this chapter we propose to deal with a series of affections associated with or allied to suppuration, and due to non-specific bacteria. These organisms, usually termed **pyogenic,** cause an inflammatory reaction in the tissues, which sooner or later is associated with liquefaction of both tissue and exudate, the liquefied material being known as **pus,** and the process which leads to its formation as **suppuration.** Any localized collection of pus in the tissues is known as an **abscess,** and this may be acute or chronic, the latter being uncommon. Sometimes the infection involves the cellular tissue of a part in a more or less diffuse manner, the pus burrowing widely; this condition is termed **cellulitis.** Constitutional phenomena are associated with these local manifestations, and may be of two types: (*a*) When toxic products alone are absorbed, resulting in **toxæmia** or some modification of the same; (*b*) and when the bacteria invade the blood-stream and become disseminated to distant parts, thereby giving rise to either **septicæmia** or **pyæmia.**

Bacteriology.—The following are the more important **pyogenic bacteria:**

1. *Staphylococcus pyogenes* (Plate I., Fig. 1) is perhaps the commonest organism of acute localized suppuration, especially in connection with the skin and subcutaneous tissues. It is a coccus of medium size which occurs in the pus in characteristic clusters, which have been compared to bunches of grapes. It stains by Gram's method, and liquefies gelatin or solidified blood-serum, as it produces a powerful peptonizing enzyme, and is readily cultivated on almost all media; it grows best when an abundant supply of oxygen is present, and on blood-agar it is actively hæmolytic, the colonies becoming surrounded by a characteristic clear zone.

Cultures on solid media develop rapidly, and the colonies spread, the surface being soon covered by a uniform thickish film of growth. This may be orange-yellow, lemon-yellow, or white in colour, and three varieties—*Staphylococcus pyogenes aureus, citreus,* and *albus*—are described.

Staphylococci are very widely distributed, being common in air, dust, etc. They are constantly found in or on the human skin, and suppurative inflammations of it and of the subcutaneous tissue

* For the significance of the term *non-specific,* see p. 10.

are generally due to them; when the inflammation is caused by other organisms in the first instance, a secondary infection with staphylococci almost always takes place later. Impetigo contagiosa, a disease due primarily to streptococci, may be taken as one example of this, and the vesicles of small-pox and vaccinia as another, for in each case a secondary staphylococcal invasion takes place. The chief skin lesions due to staphylococci are abscesses, boils, carbuncles, pustular acne, etc. In some cases diffuse spreading cellulitis may be produced by them, but this is unusual. Deep-seated suppuration, such as osteomyelitis, perinephric abscess, empyema, etc., may also be due to staphylococci; in fact, they may cause suppuration in any part of the body. Lastly, staphylococcal septicæmia, pyæmia, and ulcerative endocarditis occur, but are less common than the forms due to streptococci, and the prognosis appears to be slightly less grave.

Many cases of post-operative suppuration in which the antiseptic or aseptic precautions have failed are due to staphylococci, either alone or in admixture with other organisms.

2. *Streptococci* (Plate I., Fig. 2).—For a long time after the discovery that cocci growing in chains were associated with severe spreading infections, all organisms of this type were grouped together under the name *Streptococcus pyogenes*. It was gradually recognized, however, that some of these organisms were more virulent than others, and that immune bodies, such as bactericidal sera, which were active in certain cases of disease were useless in others. It is obvious, therefore, that different strains of streptococci of varying pathogenic power exist. This is due in part to the fact that streptococci form a heterogeneous group containing numerous different types or species, but it is also recognized and can easily be proved experimentally that the *same* strain of streptococcus may at different times show all degrees of pathogenicity, and may, *e.g.* on passage through a series of susceptible persons or animals, become progressively more and more highly virulent, as the surgeon and pathologist sometimes learn to their cost when they prick or cut their fingers whilst operating upon cases of streptococcal infection; whereas, on the other hand, such virulence may be diminished or may practically vanish when the organism is passed through a succession of subcultures outside the body.

An enormous amount of work has been done upon the classification of streptococci, but final agreement has not yet been reached upon this important subject. One of the most valuable differential tests is the capacity of the organism to produce hæmolysis *in vitro*, *e.g.* upon fresh blood-agar, and in a suitable nutrient broth-medium to which fresh red blood-corpuscles have been added. In this connection, it should, however, be noted that such hæmolysis by any organism *in vitro* should **not** be regarded as an index or criterion of its pathogenicity, and that not only certain pathogenic streptococci, but also staphylococci, sarcinæ, and even many non-pathogenic bacteria, may produce it. The fermentation of certain sugars and other

substances has also been utilized for the differentiation of streptococci.

Of the many classifications which have been suggested, perhaps the simplest and most convenient (but by no means complete or final) scheme is that of Holman, whose uses first the test of hæmolysis to divide streptococci into two main sub-groups, **hæmolytic** and **non-hæmolytic.** He then divides each of these sub-groups into eight species, *i.e.* sixteen in all, according to their fermentation-reactions with lactose, mannite, and salicin in Hiss's serum-broth medium, as set out in detail in the annexed table.

HOLMAN'S TABLE OF DIFFERENTIATION OF STREPTOCOCCI:

Hæmolysis:	Lactose:	Mannite:	Salicin:	
+	+	+	+	*S. infrequens*
+	+	+	−	*S. hæmolyticus* (1)
+	+	−	+	*S. pyogenes*
+	+	−	−	*S. anginosus*
+	−	+	+	*S. hæmolyticus* (2)
+	−	+	−	*S. hæmolyticus* (3)
+	−	−	+	*S. equi*
+	−	−	−	*S. subacidus*
−	+	+	+	*S. fæcalis*
−	+	+	−	*S. non-hæmolyticus* (1)
−	+	−	+	*S. mitis*
−	+	−	−	*S. salivarius*
−	−	+	+	*S. non-hæmolyticus* (2)
−	−	+	−	*S. non-hæmolyticus* (3)
−	−	−	+	*S. equinus*
−	−	−	−	*S. ignavus*

'+' and '−' in relation to sugars indicate *Acid-Production* and *No Acid-Production* respectively.

Hæmolytic Reaction..........in Fresh Human Red-Cell Agar.
Sugar Reactions.............in Serum-Water Media.

Of the hæmolytic streptococci, *Streptococcus pyogenes* is the commonest and most important. Closely allied to or possibly identical with it is the streptococcus of erysipelas. The serological classification of streptococci by specific agglutinating sera and absorption tests is too complex and uncertain a proceeding for ordinary clinical use, but it may be mentioned that Mervyn Gordon recognizes three main serological types of hæmolytic streptococci:

I. *Streptococcus pyogenes,* the most numerous.
II. A rare type.
III. *Streptococcus scarlatinæ.* (For a detailed account of this important organism, see textbooks of bacteriology.)

The *S. fæcalis* is probably a group of closely allied species. It is a normal inhabitant of the intestine, and occurs very commonly in wounds contaminated with fæcal material, and is usually an organism of comparatively feeble virulence. One member of the group, the *Enterococcus*, is characterized especially by its variable shape, oval or even pseudo-bacillary forms being common; the latter are often arranged in a typical 'saddle-bag' shape. It is a resistant organism, being much less easily killed by antiseptics, heat, etc., than most other varieties of streptococci. The *Micrococcus* or *Streptococcus rheumaticus*, described by Poynton and Paine, Beattie, and others, is probably a member of this group.

Streptococci grow in longer or shorter chains; but any classification according to length of chain is of little value, as this may vary not merely with the type under investigation, but also with the culture-medium. Streptococci retain the stain with Gram's method, and do not grow so luxuriantly as staphylococci on artificial media; the colonies are small and translucent; they form no peptonizing enzyme, and therefore do not liquefy gelatin.

The lesions produced by streptococci depend upon the virulence of the organism and the varying susceptibility or resistance of the patient. They may produce localized abscesses, or spreading forms of suppuration, such as erysipelas and cellulitis, lymphangitis, lymphadenitis, meningitis, etc.; whilst still more fatal streptococcal affections are septicæmia and pyæmia, including puerperal fever and ulcerative endocarditis. Non-hæmolytic varieties of streptococci may produce lesions which tend to be less acute than the foregoing, *e.g.* tonsillitis, infections of nasal sinuses, the middle ear, tooth-sockets, gall-bladder, appendix, renal pelvis, etc.; and such focal infections are not infrequently found in cases of rheumatism and its complications, including endocarditis.

3. The *Pneumococcus* (Plate I., Fig. 4) is practically always present as a normal inhabitant of the mouth. It is generally the cause of acute lobar pneumonia, and the accompanying pleurisy. It is a diplococcus, the individual cocci having usually an oval or lancet shape. When it occurs in pus or other animal fluids, it is surrounded by a clear capsule. It may be differentiated from the majority of the streptococci by its fermentation of inulin, and, unlike the streptococci, it is soluble in bile or a solution of sodium taurocholate. Four main serological types are described, of which Types I. and II. are found especially in epidemics of acute lobar pneumonia, infections with the former, *i.e.* Type I., but not the others, being often benefited by the use of its homologous serum. The pneumococcus is found in many suppurative conditions connected with the lungs, especially empyema, and often as a secondary infection in other lesions of the lung; thus, in the walls of a tuberculous cavity suppuration is very frequently due to pneumococci alone or in conjunction with other organisms. It is a common cause of middle-ear disease, and of its cranial or intracranial complications. Pneumococci also cause arthritis, which may or may not result in suppuration; it may follow an attack of

pneumonia. Peritonitis also may be due to this organism, especially in young children, and may be primary, or secondary to some pulmonary lesion. The pneumococcus sometimes enters the blood and causes septicæmia, with or without ulcerative endocarditis.

4. *Bacillus coli* (Plate IV., Fig. 4) occurs in great numbers in the contents of the healthy intestine. It is a short motile bacillus which does not form spores, and is not stained by Gram's method. It grows best in presence of oxygen, but is a facultative anaërobe; no peptonizing enzyme is produced, so that gelatin is not liquefied. It is distinguished from the typhoid-paratyphoid-dysentery group by its action on various sugars, especially by its fermentation of lactose, the latter group being non-lactose-fermenters. These bacteria are members of a large and important group of micro-organisms, which have a close morphological resemblance to one another, but differ in their chemical and serological reactions.

Under normal conditions the bacilli of the *B. coli* group, which occur in the intestinal contents, are not very virulent, but when any pathological condition arises in the gut and its resistance is lowered —*e.g.*, strangulation, ulceration, perforation, etc.—active invasion of the tissues may follow, and may lead to appendicitis, acute peritonitis, etc., any pus so formed having usually a fæcal odour. These organisms can also ascend the bile-ducts, and give rise to cholecystitis and cholangitis. *B. coli* is one of the commonest causes of pyelitis and pyelocystitis, in which it is frequently associated with streptococci.

5. *Bacillus typhosus* or its relatives of the paratyphoid group sometimes cause abscesses, especially in connection with the bones or joints, after an attack of the specific fever. In some cases the organisms may lie latent for years before suppuration occurs. It has also been proved that some persons continue to excrete these bacilli in the urine or fæces for many years after such attack; in the latter instance, the gall-bladder has sometimes been the infected focus. These typhoid and paratyphoid 'carriers,' as they are termed, may at any time initiate an epidemic of the disease.

6. *Bacillus pyocyaneus* is occasionally a cause of suppuration, *e.g.* in the middle ear, or in gunshot wounds, etc. The pus produced by it turns bluish-green when collected on dressings and exposed to the air. The discharge is often abundant, and has a characteristic musty smell. The infection is not as a rule of grave import, and is controllable by suitable drainage and antiseptics without much difficulty. This organism, however, sometimes gives rise to a general infection somewhat resembling typhoid fever, and it may then be found in the blood, fæces, and urine.

7. The *Gonococcus* (see p. 151).

Many cases of suppuration are due to a **mixed infection** with two or more of the species of bacteria enumerated above, or with some of the anaërobes described elsewhere. In other instances an abscess formed by the action of one of the pyogenic bacteria may be subsequently infected with simple saprophytes which have the power of

growing in dead pus, but cannot invade the living tissues. This is especially liable to occur in a large abscess when the drainage is insufficient, and the dressing is not performed with sufficient care. Such an accident should be studiously avoided, for lesions due to a mixed infection heal with difficulty, the tissues appearing more easily to acquire immunity against a single variety of organism than against two or more at the same time. The fact that a wound is already infected is no reason for neglecting to treat it with the fullest aseptic precautions.

I. Acute Abscess.

Ætiology.— (*a*) It may be taken as established that suppuration as met with in surgical practice is almost always due to the action of bacteria, though occasionally it may follow upon the intramuscular or other injection of certain medicaments. In some more or less quiescent abscesses, however, notably in the liver, and in pyosalpinx, no organisms can be found in the pus on microscopical or cultural examination, owing to their having been already destroyed and eliminated.

(*b*) Bacteria can reach the area which becomes inflamed either from without the body or from within. The *Staphylococcus pyogenes* is commonly present in the skin, and often on instruments, dressings, etc., and it is to infection from outside sources that most cases of post-operative suppuration are due. Suppuration and abscess-formation is particularly liable to occur in lymphatic glands, from the spread of infection in their drainage areas, *e.g.* in the axillary glands, from the fingers, etc., or in the cervical glands from the tonsils, teeth, etc.

In some cases, however, bacteria gain access to the tissues from the blood; thus a deep lesion (such as a ruptured muscle or ligament) may result in suppuration, although the skin over it is unbroken, and the intervening tissues are apparently healthy. Here we must assume the existence of auto-infection (p. 7), the bacteria reaching the blood from some pre-existing septic focus elsewhere, such as infected gums, teeth, tonsils, nasal sinuses, intestine, especially the appendix, etc.

In other cases abscesses may be due to organisms which have lain latent in the tissues, it may be, for long periods. The possibility of this, especially as a sequel of wounds of a ragged and irregular shape which have been the seat of prolonged suppuration, has already been mentioned (p. 7), and it is a factor that has to be carefully considered in deciding the best time to perform secondary plastic or other operations, *e.g.* on bones or nerves; usually it is wise to wait for from three to six months, special attention being given to the patient's general health beforehand. Bruising of the part without breach of surface, or opening up the parts again by an operation, or even serious depreciation of the general health without any wound, may suffice to light up active suppuration once again. Another example may be seen in the bone abscesses which sometimes

develop months or years after an attack of typhoid fever, and are due to the typhoid bacillus, though in this case we cannot always exclude the possibility of a subsequent infection.

Abscesses of a very different nature occur in ulcerative endocarditis: and in pyæmia, where pyogenic bacteria are carried elsewhere by the infected and breaking-down blood-clot in a thrombosed vein implicated in some primary suppurative focus. These are termed secondary embolic abscesses.

(*c*) Sterilized foreign bodies (*e.g.* silver wire or glass splinters) do not produce suppuration, except, in the rarest of cases, by auto-infection. Thus, a ragged splinter of glass, 1¼ inches long and 1½ inches wide, the result of the bursting of a soda-water bottle, was cut out of the neck of an hotel porter ten months after it had entered; it was encapsuled and had caused no trouble. This fact is constantly utilized in surgical practice; deep layers of the tissues are brought together by carefully sterilized buried sutures, and divided structures such as bones, ligaments, etc., can be approximated and held in position by wire, screws, pegs, or other buried appliances, which would cause serious trouble but for their complete sterilization.

Formation and Structure of an Acute Abscess.—The bacteria which have gained access to the tissues multiply and produce toxins which are diffused into the surrounding structures, giving rise to acute inflammation; the vessels dilate, acceleration of the blood-stream occurs, followed by retardation and thrombosis, and by migration of leucocytes. More vigorous action of the toxins on the injured tissues destroys their vitality, usually by a process of coagulation-necrosis. A microscopical section through the lesion at this stage will show two well-differentiated zones (Fig. 18): a central area in which the tissues are dead, have lost their staining properties, and contain the pyogenic bacteria: and a peripheral zone of acute inflammation, which fades gradually into the surrounding healthy tissues. This inflamed zone is thickly infiltrated with leucocytes, mainly of the polymorphonuclear variety, since the products of pyogenic bacteria have special attractive (chemiotactic) powers over this form of leucocyte.

The central necrotic mass which contains the bacteria is at this stage still attached to the surrounding living tissues, and if the lesion is incised it will appear as a slough, which can be removed only with difficulty. But this condition soon changes; as a result of increasing exudation, especially of plasma, the tension in the inflammatory focus becomes so great that the cohesion of the tissues around the central slough is destroyed, and a third zone—of polymorph leucocytes in fluid—is formed between it and the inflamed outer zone.

The fate of the slough varies according to circumstances. It may occasionally be recognized when an abscess is opened—*e.g.*, as the core of a boil—but in most cases it is absorbed by the leucocytes or digested by the enzymes formed by many pyogenic bacteria and by dead and disintegrating leucocytes. It may even happen that no

definite slough is formed, the earliest effect of the bacteria being to attract the leucocytes in vast numbers into inflamed but still living tissues—a process of purulent infiltration rather than of abscess-formation.

An abscess, then, consists of a collection of leucocytes suspended in fluid and surrounded by a zone of inflamed tissue. The leucocytes, disintegrated tissue, and fluid are collectively termed **pus,** and the characteristic cells of the pus from an acute abscess are the polymorphonuclear leucocytes, then known as pus-cells. Many of these

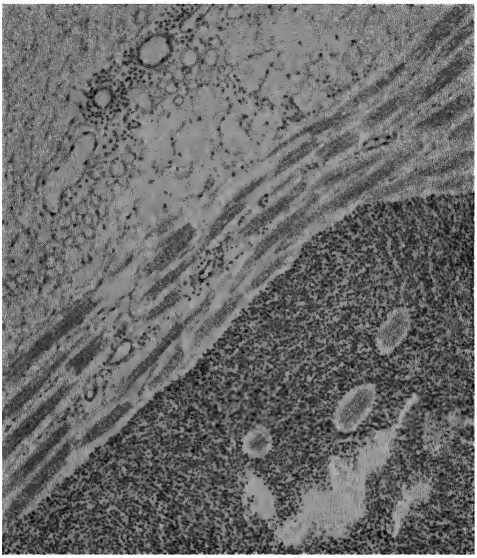


FIG. 18.—FORMATION OF ABSCESS IN MUSCLE AT FORTY-EIGHT HOURS.

The pus-cells of the abscess are seen in the lower part, which also contains some fragments of necrosed muscle. The band of muscle passing diagonally across the figure, and the fatty areolar tissue above it, show some inflammatory œdema and infiltration with leucocytes.

are dead, having been killed by the toxins (as can be seen from their loss of motion when the pus is examined on a warm stage), and others undergo various degenerative changes, especially fragmentation of their nuclei. Some of them may contain bacteria.

At first the abscess may extend rapidly, but after a day or two (in most cases) a certain amount of local immunity is produced, and the abscess spreads more slowly. This is an indication of the fact that the tissues, which were at first overwhelmed by the action of the bacteria and their toxins, are now carrying on the contest on more even terms. At this period the cavity becomes lined by

granulation tissue (Fig. 19), which forms a thick, soft layer of velvety appearance and bright pink colour. It is composed of large numbers of loops of newly-formed bloodvessels embedded in a mass of leucocytes and tissue-cells in a state of active proliferation. Its appearance does not necessarily indicate that the abscess has entirely ceased to spread, for the toxins may still be powerful enough to kill the delicate newly-formed tissue; but in most cases it is the first indication of repair and of the ultimate victory of the tissues. Leucocytes continue to pass from these newly-formed thin-walled vessels into the abscess cavity, being attracted chemiotactically by the substances present in the pus; hence the layer of granulation tissue appears to 'secrete' pus, and was formerly called a 'pyogenic membrane.' Its formation was anxiously looked for in the days when suppuration was considered essential in the healing of wounds, since it opposes a barrier to the absorption of bacteria and their toxins. Thus the formation of thick, creamy pus of a yellowish colour was considered a sign that the patient was practically out of danger of 'blood-poisoning,' and the pus was termed 'laudable.'

Abscesses may not spread equally in all directions, since certain structures, especially bone and fascia, are more resistant than cellular tissue or fat. The process of extension tends to continue along the line of least resistance until the abscess points at some surface, and finally bursts through the skin or into the alimentary canal or other cavity. When the pus and the contained bacteria and their toxins alike are able to escape externally, the erosive action on the pyogenic membrane becomes less profound, and the contest between the defensive powers of the tissues and the destructive powers of the bacteria, in which the latter were at first victorious, turns in favour of the tissues. The bacteria which remain are attacked with greater effect by the leucocytes, and are gradually removed; the supply of toxin diminishes; the inflammatory process ceases, and finally organization of the granulation tissue commences. This begins at the deepest part of the abscess cavity, the walls being kept apart from one another by the pus which is still being formed, though in gradually diminishing quantity, and the process is facilitated if efficient drainage is provided.

Occasionally the defensive powers of the body are sufficient to kill off the bacteria after pus has been formed, and before it has escaped. When this happens, the pus may become absorbed and the cavity obliterated, or the fluid part only may undergo absorption, and the leucocytes and débris (which undergo fatty degeneration) remain as a cheesy, structureless mass. In either case the abscess wall organizes into fibrous tissue, constituting a deep scar, in the centre of which may be the inspissated pus. This rarely happens, except in the abdomen, and then usually in connection with the appendix, Fallopian tube, or liver. In a few cases bacteria may become enclosed in the newly-formed connective tissue and remain in a latent condition, but still capable of again becoming active on suitable provocation.

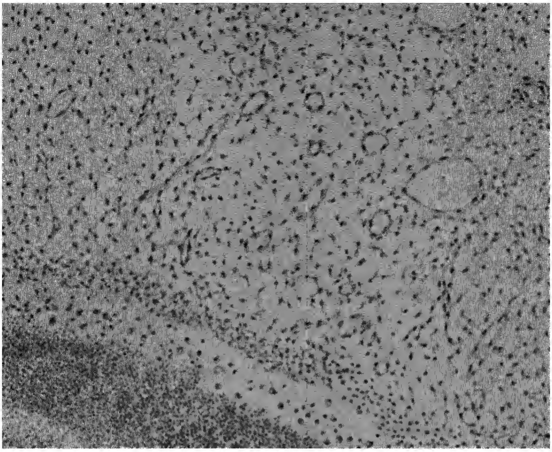


FIG. 19—RESOLVING ABSCESS AT FOUR DAYS.
Early vascularization and young granulation tissue is seen above.

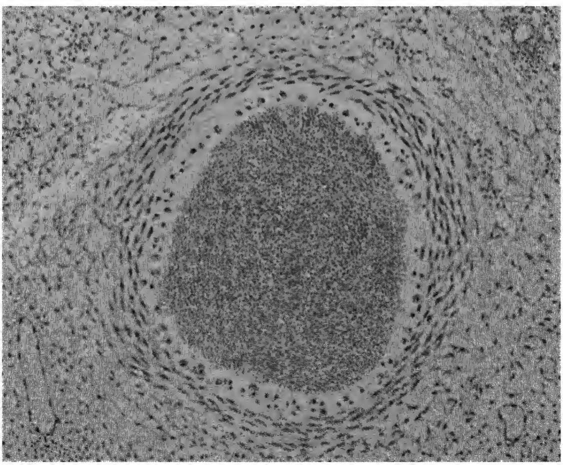


FIG. 20.—RESOLVING ABSCESS AT EIGHT DAYS.
The central pus is undergoing absorption and is surrounded by a layer of young fibroblasts. Compare with Fig. 19 above.

The **Clinical Signs** and **Symptoms** of an acute abscess may be described under three headings:

1. **The local signs** consist of a patch of inflamed tissue, indicated by heat, pain, redness, and swelling—such swelling being at first hard and brawny, but, when pus forms, the centre becomes soft and elastic, whilst superficial œdema is more marked. The intensity of the pain, which is throbbing in character, depends upon the density of the tissue affected and the supply of sensory nerves to the part, suppuration beneath a resisting membrane, such as the palmar fascia, being always intensely painful. **Fluctuation** is the most characteristic sign of the presence of fluid; it is obtained by making firm pressure with the finger or fingers of one hand on one part of the swelling, whilst the fingers of the other hand placed on another part receive the impulse transmitted across the intervening space in the form of a fluid wave. Some soft solids give a sensation of fluctuation—*e.g.*, lipomata and soft, rapidly-growing sarcomata; whilst, on the contrary, it may be absent when the fluid is under great tension, or surrounded by a thick wall, or widely diffused in such a structure as the glandular tissue of the breast.

Sometimes, when the pus is small in quantity, all that can be detected is a feeling of elastic resistance in the centre of the brawny hyperæmic mass; but this, to the practised finger, is quite as conclusive of the presence of fluid as fluctuation. When the pus is placed deeply under muscular and fascial planes, very careful examination may be needed in order to determine its presence; the surgeon must not be misled by the sense of fluctuation obtained across the fibres of a muscle; none is noticed, however, by palpating along the course of its fibres. Marked and increasing œdema is frequently conclusive of the presence of deeply-seated pus—*e.g.*, in acute osteomyelitis and suppurating mastitis.

If left to itself, an abscess tends eventually to **point** and **burst.** As it increases in size, it spreads along the line of least resistance, and so may either find its way direct to the surface, or may burrow along muscular and fascial planes, or into adjacent cavities. The actual bursting of an abscess is often due to some injury—it may be a slight one—usually preceded by superficial ulceration or necrosis.

2. **Pressure effects** are due mainly to the mechanical influence of the swelling upon surrounding structures. The most evident are those due to the irritation of nerves, as a result of which neuralgic pain may be present, or the patient may refer the pain to some distant unaffected region. In some cases, where large bloodvessels traverse the suppurating focus, the tissues surrounding them may be destroyed, leaving them exposed in the abscess cavity as bands. Thrombosis and subsequent obliteration may result, especially in the veins; or occasionally hæmorrhage follows, due to erosion of the wall (suppurative periarteritis or periphlebitis), preceded perhaps by dilatation of the vessel, owing to loss of its external support.

3. **The general effects** of the formation of an acute abscess of sufficient severity are fever, sometimes amounting to a **rigor,** and

leucocytosis. A **rigor** consists of a definite series of phenomena, due to stimulation of the thermogenic centres by an accumulation of toxin in the blood. It is ushered in by a feeling of intense cold and discomfort; the features are pinched, and the teeth chatter. The skin, however, feels dry and hot, and the temperature of the body rapidly rises. The sensation of cold is due partly to the contact of the hot, dry, unperspiring skin with the relatively colder external air, and also possibly to the condition of superficial anæmia which is present. After this stage has lasted a variable period, the patient gradually begins to feel warmer; the face becomes flushed; the temperature ceases to rise, and the skin commences to act. Finally there is a rapid fall of temperature accompanied by profuse perspiration, which probably assists in the elimination of the toxin, but leaves the patient more or less exhausted. For **leucocytosis** and its value in diagnosis, see p. 49.

Pus and its Constituents.—Pus is a thick, creamy fluid, having a specific gravity of about 1030, an alkaline reaction, and containing 85 to 90 per cent. of water. If allowed to settle, it separates into two layers, an upper or fluid part, the liquor puris, which is usually somewhat opalescent, and a deposit of a grayish- to slightly greenish-yellow colour, which is usually more bulky than the fluid portion. The liquor puris is derived from the plasma exuded from the vessels. It may undergo coagulation after removal from the body, a soft clot being formed. Frequently, however, this does not happen, perhaps because it has already coagulated within the abscess, and the resulting fibrinous network has been dissolved by peptonizing ferments, or destroyed by the leucocytes. It consists chemically of an albuminous fluid very similar to serum, but more dilute, and contains bacterial toxins, enzymes, proteoses formed by the digestion of proteins, etc. Sometimes (when the abscess involves a region containing fat) a few globules of oil float on the surface or occur in an emulsified form in the fluid.

The deposit consists in the main of polymorph leucocytes, most of which, as has been already pointed out, are dead and degenerated, whilst a few may still be living and capable of spontaneous movement. In addition, there are nuclei and other fragments of cells from the tissues, shreds of fibrous tissue, granular débris, and bacteria. Red blood-corpuscles are often present.

Muco-pus is the discharge from inflamed mucous membranes; it is sticky or glairy from the presence of mucus. **Sero-pus** is thin and more liquid from an excess of serum; it is usually derived from serous membranes. The term **Sanious** is sometimes applied to pus which is thin, irritating, and perhaps tinged with blood. **Blue** or **bluish-green** pus owes its colour to the presence of *B. pyocyaneus* (p. 64).

Occasionally an abscess contains not only pus, but also **gas**. This may be due to the existence of direct communication with a hollow viscus—*e.g.*, the stomach or intestine—and hence is met with in some cases of subphrenic abscess. In some of the many types of

abscess associated with appendicitis the gas is due to the activity of some member of the *B. coli* group, either alone or mixed with other bacteria. In the limbs it is usually the result of infection with gas-producing anaërobic organisms—*e.g.*, the *B. perfringens* or *B. œdematis maligni*—and is associated with an acute spreading cellulitis or gangrene; occasionally it develops in an abscess which is localized and has no connection with the bowel, and is probably of pyæmic origin.

Treatment of Acute Abscess.—When an inflamed area is threatening to suppurate, the formation of pus can sometimes be **prevented** by elevation and rest of the part, together with the application of evaporating lotions and the administration of a dose of stock staphylococcal or mixed staphylococcal and streptococcal vaccine. Bier's treatment by induced hyperæmia may also be useful.

In a few regions of the body, pus may be **absorbed** after its formation, but only when situated in a cavity of highly absorbing powers, such as the anterior chamber of the eye (hypopyon) or the peritoneal cavity.

As a rule, however, one relieves pain and encourages suppuration by applying fomentations (medicated with opium or belladonna) or poultices to the part, and then, as soon as pus is present, an incision is made to **evacuate** the abscess cavity. The opening must be large enough to prevent re-accumulation: it should be placed at a spot suitable for drainage, but as far as possible from sources of secondary contamination, and in such a direction that movements of the part do not close it. Where the opening is not dependent, it may be desirable to make a counter-opening by pushing the finger or a probe through the abscess wall amongst the tissues, making it protrude beneath the skin at some dependent position, and cutting down upon it in this direction. In dealing with deep abscesses in dangerous regions, Hilton's method may be advantageously employed. This consists in dividing merely the skin and superficial structures and then thrusting a pair of sinus or dressing forceps into the abscess cavity. On separating the blades forcibly a sufficient opening is made to insert a finger, or a drainage-tube. Rigid aseptic precautions must be taken in opening abscesses, for, although bacteria are present, it is most essential that no fresh organisms be admitted, thereby giving rise to a mixed infection, the presence of which is most unfavourable to rapid repair. When an abscess is evacuated, it is always advisable to have the pus bacteriologically examined, and an emulsion of the causal organisms reserved for the preparation of an autogenous vaccine, which will thus be available, if necessary, for the further treatment of the case, and for the prevention of possible recurrences.

Any sloughs present should be removed, and, when the abscess has burrowed, or if the cavity is large, it should be gently explored, but adhesions or bands crossing it should not be indiscriminately broken down, as they may contain large blood-vessels. All that is subsequently needed is to arrange for drainage, as by inserting a rubber or glass drainage-tube or a slip of rubber or protective, and to prevent a mixed infection by a carefully

applied antiseptic or aseptic dressing, or by packing the cavity with gauze soaked in an iodoform emulsion (10 per cent.). There is often a considerable loss of blood during the first twenty-four hours from the capillaries in the abscess wall owing to the sudden relief of tension; but this usually ceases of itself, or yields to moderate pressure. When once the abscess has been evacuated and drainage provided, if external contamination (mixed infection) has been avoided, the suppurative process should rapidly subside, the discharge becoming serous, and the wound closing and healing, and this in spite of the fact that bacteria are for a while present; they are evidently unable to develop or do any harm as the result of a local immunity. An abscess cavity which has contained foul or stinking pus usually runs a healthy course if aseptic conditions are maintained, *e.g.* if no communication with the bowel exists, the discharge becoming free from smell in a few days. Infection with *B. pyocyaneus* is best treated by the application of eusol (5 per cent.) fomentations changed every four hours; they should be thick and of sufficient size. Deep wounds or sinuses should be irrigated with hot eusol.

The persistent discharge of pus from an abscess which has been opened means either that the opening is too small, or that pus is pent up in an imperfectly draining loculus, or that a mixed infection has occurred, or occasionally that the vital powers of the patient are so deteriorated that it is difficult to establish healthy repair, or that the part is not kept at rest. Free drainage, the improvement of the general health, and keeping the affected part at rest are essential elements in the successful treatment of an abscess. A small opening must be enlarged; loculi must be drained, and, if need be, a counter-opening made. Any foreign body or dead material, *e.g.* a bony sequestrum, if present, requires removal. Debilitated patients may sometimes need to be sent to the country or seaside before healing will occur.

II. Chronic Abscess of Pyogenic Origin.

A chronic abscess may be defined as a collection of pus which forms slowly and without any signs of active inflammation, so that it is sometimes termed a 'cold abscess.' Although the majority are tuberculous in origin, a few are non-tuberculous and due to the liquefaction of other granulomatous masses, to an infection with pyogenic bacteria of low vitality, or to chronic pyæmia. The clinical phenomena are alike in the two types, and will be dealt with later (p. 192), but there is one important distinction between them, in that the lining membrane of the pyogenic variety is merely granulation tissue more or less active, whilst in the tuberculous form it contains living tubercle bacilli. Hence, whilst a simple incision under aseptic precautions may be all that is required in the former, the latter also needs treatment directed to its tuberculous origin.

Sinus and Fistula.—When an abscess, acute or chronic, has been opened, and does not heal completely, a communication often

persists between the original seat of the disease and the exterior, which is known as a sinus or fistula. A **Sinus** is a narrow track lined with granulations, penetrating into the tissues, open at one end and closed at the other; the discharge may be purulent or merely serous. A **Fistula** is an abnormal communication, congenital or acquired, between two cavities, or between a cavity and the external surface. When such conditions result from the non-closure of an abscess of pyogenic origin, the walls consist of an external fibro-cicatricial layer, and an inner lining of granulation tissue. Should the abscess have been of tuberculous origin, the lining membrane will also contain tubercles.

It is often a matter of difficulty to secure the healing of a sinus or fistula, and the following are the main causes of their non-closure: (1) The presence of some chronic irritant in the depths of the wound, such as a piece of clothing, a catgut ligature, a piece of silk or the silver wire used in an operation, or of some diseased tissues, such as a fragment of dead or carious bone or, in the case of the jaws, a septic fragment of broken tooth; (2) the irritation of discharges finding an exit through the abnormal opening, such as urine, fæces, or fœtid pus; (3) insufficient drainage of a deep cavity, so that there is always a certain amount of tension in the wound; (4) want of rest to the part, due either to voluntary movements, as in the limbs, or to involuntary muscular action in the immediate neighbourhood, as in fistula-in-ano; (5) tuberculous infection of the wall, or a tuberculous deposit at the bottom of the sinus, or an analogous actinomycotic or some similar infection; (6) the growth of epithelium down the sinus or round the margin of the fistula; (7) the presence around the sinus of dense sclerosed fibrous tissue which prevents contraction; or (8) constitutional debility.

The orifice of a sinus often looks depressed from the amount of infiltration around, but when the surrounding tissues are healthy, puckering in of the orifice is a good sign; in cases where foreign bodies are lodged within, or where diseased bone exists, it is usually surrounded by prominent fungating granulations.

Treatment.—The removal of the cause should be the first aim in dealing with a discharging sinus or fistula. Foreign bodies or dead bone (if loose) must be removed, and diseased bones or tissues suitably treated. Efficient drainage is provided by dilating or incising the passage, or by providing a counter-opening in a dependent position. The granulation lining may need to be scraped away, and the raw surface disinfected by liquefied carbolic acid or sulphate of zinc solution (40 grains to 1 ounce). Sometimes the cavity is packed with gauze soaked in a hypertonic solution, such as glycerine and iodoform emulsion or 5 per cent. saline solution, and the general health is improved. Zinc ionization is sometimes useful. Rest to the part is provided by bandaging or by a suitable splint. Occasionally it is possible to excise the lesion completely and close the wound.

Should a fistula have become lined with epithelium, the edges will

require paring, and some form of plastic operation must be undertaken to close the opening.

Sinuses often react well to vaccine treatment, and this is especially the case with those left after empyemata, when one or more injections of moderate doses of the causal organism will sometimes prove efficacious. Tuberculous sinuses, such as may be left after suppuration of glands in the neck, etc., are occasionally curable by the use of tuberculin.

Results of Long-continued Suppuration.—In certain cases, even though an abscess is treated antiseptically, and the formation of pus has ceased, the wound may not heal for months, but the discharge is merely serous, and, unless other organs and tissues are involved (a tuberculous fistula-in-ano, for example, may be secondary to tuberculous disease of the lung or intestine, or both, from the swallowing of infected sputum), no constitutional results may be manifested. The temperature remains normal, and the general health unimpaired, if no other disease is present. Should a tuberculous abscess become infected with pyococci, or a mixed infection occur in a pyococcal abscess, the discharge of pus continues or reappears, and fever to a varying degree develops. When an extensive or deep abscess is thus involved, the discharge may become very profuse, high fever may supervene, grave visceral changes may follow, and the patient may lose his life through toxæmia and exhaustion. Long-continued suppuration is always an evidence of persistent infection, and amongst the conditions which arise therefrom may be mentioned hectic fever and waxy disease of the viscera.

Hectic Fever may be defined as a chronic toxæmia due to the continued absorption of small doses of toxins, and is met with in any condition of chronic infection—*e.g.*, after acute, or in chronic suppurative affections of bones or joints, in tuberculous disease of the lungs, where secondary mixed infection has occurred, and in chronic syphilitic or cancerous ulceration. It is characterized by a diurnal elevation of temperature (Fig. 21) during the afternoon or evening, when the face becomes flushed (hectic flush of the cheeks), the eyes are bright and sparkling, the pupils dilated, and the patient feels better and stronger. The pulse, however, is small, compressible, and ten or twenty beats quicker than it should be. This condition continues till late in the night, by which time the temperature may have risen four or five degrees. In the early morning it falls as rapidly as it had formerly risen, and usually drops to the normal, or even below it, and this is accompanied by a profuse perspiration, which leaves the patient in a much exhausted condition. Day by day this continues, the fever and sweating together causing rapid and marked emaciation.

Waxy, Amyloid, Albuminoid, or **Lardaceous Disease** of various organs is a condition due to the deleterious effects of toxic compounds circulating in the blood,* whereby the delicate connective tissue of

* Waxy disease may also be due to syphilitic infection, and it also occasionally occurs as a complication or sequel of repeated attacks of acute rheumatism.

the walls of the arterioles, and subsequently the perithelial coats of the capillaries and the connective tissue of the walls of the veins as well as, later, of the larger arterioles and small arteries, are converted into or infiltrated with a waxy substance, from which lardacein, an extremely insoluble protein body, may be obtained. It may also come to involve the connective-tissue framework, basement-membranes, etc., but never the cytoplasm of the special cells, of certain viscera. The name 'amyloid' is an entire misnomer, as this material is in no way akin to starch. It occurs as a waxy homogeneous material, becoming a dark mahogany brown on the application of tincture of iodine, and an inky blue when sulphuric acid is subsequently added. With methyl-violet the amyloid substance is

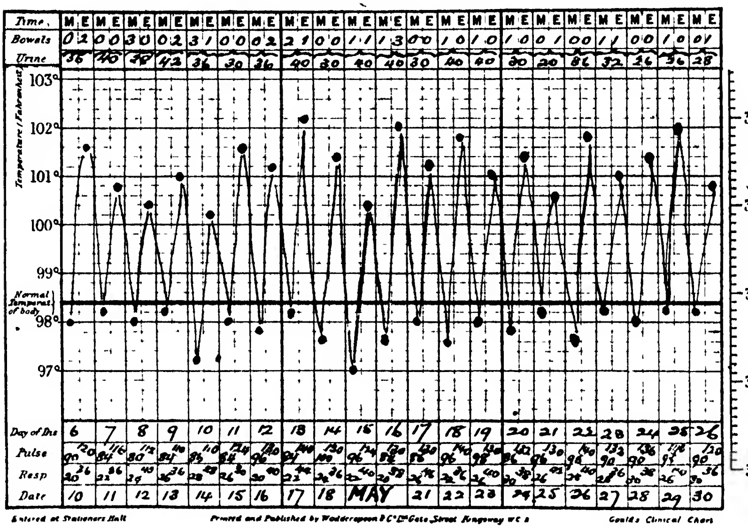


FIG. 21.—TEMPERATURE CHART OF HECTIC FEVER.

coloured ruby-red, whilst normal tissues are stained blue. The organs mainly affected are the kidneys, spleen, liver, and villi of the intestines. The **liver** usually becomes uniformly enlarged to a considerable degree, often reaching from the fifth rib to the umbilicus or lower; it is firm in consistency, like indiarubber, and waxy-looking on section. The arterioles of the portal tracts and the capillaries in the intermediate zone of the lobules are those first affected. The secreting cells of the liver, kidneys, etc., may undergo compression-atrophy and other secondary degenerative changes, but are themselves never invaded by the waxy disease. The glycogenic and bile-producing functions are interfered with, so that the digestive processes, and especially the power of absorbing fats, is impeded, although the appetite may remain good. The **kidneys** become

similarly enlarged, the change usually commencing in the arterioles leading to the glomeruli, but the intertubular capillaries and the basement-membranes of the tubules are also early affected. In this stage the urine is very abundant (from the increased filtration through the degenerated vessel walls), pale, limpid, and containing a few hyaline casts and fatty cells; later on, when secondary degenerative fatty and catarrhal changes have attacked the tubules, there is less urine, with a higher specific gravity, and a considerable amount of albumin. The **spleen** increases in size, but not always to so great an extent as the other viscera, the Malpighian bodies being the chief seat of the change. The capillaries in the **villi of the intestines** become lardaceous, and allow of an increased transudation of the fluid parts of the blood, resulting in diarrhœa, which may also be in large part due to the secondary catarrhal inflammation of the mucous epithelium which usually supervenes. The absorption of nutriment is thereby much lessened, and thus both by increased excretion and diminished absorption of food the strength of the patient is steadily undermined.

Amyloid changes in the viscera, far from being a contra-indication to operation, are rather to be considered as a sign that radical treatment is urgently necessary, unless the general condition of a patient is such that he cannot stand the strain of it. If by an operation—*e.g.*, excision or amputation—the local disease can be eradicated, the amyloid change in the viscera, if still only in its earliest stage, may disappear. At the same time one must not forget that the kidneys are seriously damaged, and that antiseptics, such as carbolic acid, which are absorbed into the blood and eliminated in the urine, may light up an acute nephritis with possibly fatal results.

Much attention has been given of recent years to the widespread influence in the body of the absorption of organisms and their toxins from foci of **persistent bacterial infection,** whether suppurative or not; and many forms of disease have been traced to this cause. Dr. William Hunter* was one of the first to call attention to this matter, especially to the influence of chronic dental sepsis upon the constitution of the blood, but since that time the whole subject has taken on a wider outlook.

The primary foci are to be looked for in various regions, but amongst the more important may be mentioned: (1) **Dental sepsis,** due either to apical infection with associated bone lesions (for the diagnosis of which, and for the detection of buried septic roots, and unerupted teeth which may have become infected, a complete X-ray examination of the teeth and jaws is essential), or to **chronic gingivitis** or **pyorrhœa,** either superficial or deep (see Chapter XXVIII.). The organisms most commonly present in these cases are streptococci of the non-hæmolytic types. (2) **Naso-pharyngeal sepsis,** generally associated with chronic sinus trouble, is usually of streptococcal, sometimes of pneumococcal, origin. (3) **Chronic tonsillitis** is often characterized by the presence of plugs of infective material

* *Trans. Odontol. Soc.*, 1899, xxxi., p. 92.

buried deeply in the crypts and often encapsulated, although the tonsil itself may not be greatly enlarged, and may even be atrophied and sclerosed. (4) Various **intestinal** lesions, such as chronic appendicitis, colitis, cholecystitis, etc., may lead to general absorption; these are often secondary to dental lesions, but may persist when the latter have been removed or cured. (5) Chronic streptococcal lesions of the **urinary** and **genital tracts** in both sexes may produce similar results. In this connection, it may be noted that streptococci in very small numbers may find their way into the circulation from areas of focal sepsis, and be excreted from the blood by the kidneys, and thus be found in the urine if catheter-specimens are taken with extreme care, and a sufficient amount of centrifugalized deposit is inoculated into suitable media. In rheumatic cases, this is most likely to be successful during an attack or exacerbation of the symptoms, as such streptococci may appear only intermittently in the urine. An autogenous vaccine prepared from them is often of great value in treatment.

It is interesting to note that many of the causal organisms are normal inhabitants of the mouth or intestine, and lead to trouble only when absorbed into the tissues. Much depends on their virulence, which is often increased by development in the body, especially in bony tissues, as at the apices of teeth. The amount and duration of the absorption is also of significance; some patients have more resistance than others, and this may be seriously diminished by the influence of the organisms upon the blood and blood-forming tissues. Streptococci not infrequently give rise to a leucopenia, which may be of grave import, and may indicate that operative interference should not be lightly undertaken; it may be desirable to remove one diseased tooth at a time, or only a few teeth, and not a whole series. Inherited tendencies may also influence the results; some individuals may inherit weakness of certain organs, and these are more liable to be affected than others, as, for instance, patients in whom achlorhydria is present are more liable to develop pernicious anæmia as a sequel of dental sepsis. Traumatism may also act as a determining factor, as in arthritis or acute osteomyelitis from auto-infection.

Only a few results of the absorption of bacteria and their toxins from dental or other sources can be mentioned here. (1) The direct passage of bacteria from the mouth or naso-pharynx is likely to have an injurious effect upon the mucous membrane of the stomach or intestinal tract, and thus chronic gastritis, gastric or duodenal ulcers, appendicitis, or colitis are liable to follow, as also the extension of such infection along the biliary or pancreatic ducts, thus determining disease of the liver or pancreas, and perhaps leading to the production of gall-stones or of diabetes. In this connection it is important to emphasize the necessity for careful treatment of teeth and disinfection of the oral cavity before all operations on the mouth, such as excision of the tongue or tonsils, and also prior to gastro-enterostomy. (2) The air-passages similarly may be infected by

direct extension from oral sepsis; tracheitis with an abundant mucopurulent expectoration is often due to this cause, as is also aspiration-pneumonia after an anæsthetic. (3) The effect upon the blood of chronic absorption of bacteria and their toxins is to produce a secondary anæmia, mild or severe in type (the 'septic anæmia' of Hunter), characterized by a somewhat varying blood-count. Chronic infection, *e.g.* of the sockets of devitalized or 'dead' teeth, with the non-hæmolytic streptococci (*S. salivarius, S. mitis, S. fæcalis,* etc.) which are so frequently associated with secondary 'rheumatic' and 'rheumatoid' manifestations, usually produce a varying degree of anæmia, especially a hæmoglobinæmia accompanied by leucopenia. When the streptococcus is of the hæmolytic type, the red cells are greatly reduced in numbers, and the hæmoglobin may not be more than 60 or 70 per cent. Leucocytosis may be present, involving either the polymorphs or the lymphocytes; and in bad cases a leucopenia may exist, affecting the former rather than the latter, which may be relatively increased in number. (4) As regards the body generally, one can only say here that there are few organs which cannot be markedly affected, and the possibility of absorption of toxic material from some hidden or obvious source or sources—for these are often multiple—should always be considered. In particular one would draw attention to the grave influence of such infections in the development of all the so-called rheumatic lesions, including synovitis, arthritis of many types, fibrositis, neuritis, perineuritis, endocarditis, etc. The development of chronic osteo-arthropathy (*q.v.*, p. 670) has long been recognized as dependent on toxic absorption, and modern ideas as to the origin and treatment of many chronic lesions of bones, joints, fasciæ, ligaments, and of the eye, etc., is merely an extension of the same principle.

For treatment of the various lesions, see under special headings.

III. Cellulitis.

Cellulitis (or, as it used to be termed, diffuse phlegmon) is a disease characterized by the existence of a spreading inflammation of the subcutaneous or cellular tissues, due to the activity of pyogenic organisms, and running on to suppuration, sloughing, or even to extensive gangrene.

Causation.—The one essential is the infection of the cellular tissues with organisms which have gained an entrance through an operation wound, or through an accidental breach of surface, even through some slight graze, prick, or scratch. Deep infected wounds which are not properly drained are amongst the most favourable for the development of this condition, especially if the general health of the individual is bad, if he is suffering from albuminuria or diabetes, or if his surroundings are of an insanitary nature. Where much loose cellular tissue is present, inflammatory phenomena may readily supervene, from the absorption of bacteria from neighbour-

ing contaminated structures—*e.g.*, pelvic cellulitis arising from an infected uterus, or cellulitis of the neck from an ulcerated throat.

Bacteriology.—The *Streptococcus pyogenes* is the organism most frequently found in cases of cellulitis, particularly when there is much tendency to spread. In some of the more localized forms the *Staphylococcus pyogenes* is present.

Clinical History.—The symptoms necessarily differ according to the site of inoculation and the virulence of the causative organisms, and hence anything from a localized suppuration to the acutest form of spreading gangrene may result. In a case of moderate severity, due to a prick or abrasion which has become infected, there is often a period of quiescence for a day or two, and the site of inoculation shows but slight signs of inflammation, beyond being a little tender. The patient at first may feel only slightly unwell, but the symptoms, both general and local, tend to become progressively more marked. Fever is almost always present to a greater or less degree, and in the more severe types one or more rigors occur, or the temperature may be subnormal, owing to the intensity of the toxæmia. The affected part is found to be hot, tender, and infiltrated; if superficial, it looks red and angry, and feels brawny. In some cases local hæmorrhages or petechial spots are found in addition to the other inflammatory phenomena. The course of the case depends to a very large extent upon the treatment adopted; if freely incised, the process may become limited, and even although suppuration and sloughing occur, repair is readily effected. If, however, the virus is very active, or the patient's power of resistance low, or if the inflamed area is left to itself or merely poulticed, the process may spread rapidly, and extensive destruction follow. Intense pain and sleeplessness, accompanied perhaps by delirium, form the most prominent symptoms, and these, together with the toxic fever, rapidly exhaust the patient's strength. Suppuration at length occurs, but is often of slow development, and the swelling may remain hard and brawny for some time in such a region as the neck, with no evidence of softening, so that it may be difficult to determine whether pus is present or not. The infiltrated cellular tissues are likely to slough, and in a limb extensive subcutaneous necrosis may occur, although the skin only gives way in places; hence it is often possible to pass a probe between the skin and the deep fascia over a considerable area. Sometimes the chief focus of inflammation may be found at a distance from the original site of inoculation, whilst the intervening portion is but little affected, or shows the characteristic features of acute lymphangitis. This is due to the organisms being transmitted along the lymphatics, and then arrested at a higher level. Occasionally the trouble spreads along the deeper areolar planes, or even along muscular bellies, which may be infiltrated with pus or may actually slough. In all these more severe forms the patient runs a considerable risk of developing general septicæmia or pyæmia.

Treatment.—Careful attention to the principles of antiseptic surgery can prevent the occurrence of cellulitis to a very large extent in casualty and operative work. Abrasions and small punctured wounds should always be protected, and all penetrating injuries disinfected, especially if the patient runs exceptional risk of infection owing to his occupation or surroundings, or to the nature of the injury. Should inflammatory phenomena supervene, the application of warmth and moisture in the form of fomentations or poultices is required, whilst attention should be given to free action of the bowels and to the general health. If the condition spreads and suppuration is threatening, free incisions in the long axis of the limb should be made into the brawny tissues, so as to give exit to the serous and irritating discharges, but the deep fascia must be avoided. The wounds thus made are lightly packed with gauze soaked in a hypertonic solution (*e.g.*, 5 per cent. salt solution, or 10 per cent. glycerine and iodoform emulsion), over which the usual dressings are applied. The object of this is to drain the fluids from the parts by capillary action, and hence an effective junction must be maintained between the gauze drain and the surrounding dressing. It is often wise to incorporate a piece of sterilized gutta-percha tissue or mackintosh in the outer folds of the dressing, so as to keep the parts moist and encourage a free discharge. Packing with gauze soaked in flavine is also useful, or the Carrel-Dakin method of treatment may be sometimes employed with advantage. Extension of the infection requires further incisions, and the surgeon must follow up the disease with the knife. At the same time the patient's health and strength must be maintained by the administration of suitable food and drugs, and collosol manganese may be useful.

After the bleeding caused by the incisions has ceased, the limb should be immersed several times a day in a warm bath for not more than two hours so as to dilute the toxins and render them innocuous. Sterilized normal salt solution at a temperature of 105° to 110° F. does perfectly well, or weak solutions of iodine or eusol may be used; but antiseptics are of little value in checking the disease when once started; the surgeon has to depend mainly on relief of tension, the removal of toxic discharges, and the antiseptic power of the tissues. At the same time the utmost care must be taken to prevent any fresh or mixed infection.

The **general** treatment is that indicated for septicæmia (p. 97), including the use of antistreptococcal serum and perhaps immunotransfusion. Plenty of simple nourishing food is administered, and such drugs as are required to procure sleep and secure efficient action of the bowels, skin, and kidneys.

Special Varieties of Cellulitis.

Cellulitis of the Axilla not infrequently follows an infected wound of th hand, such as occurs at operations or post-mortems, and hence is not uncommon in medical practitioners, students or nurses. It may also be caused by extension from an axillary lymphadenitis. The tissues of the armpit become hard and brawny, the pain is severe, especially on movement of the shoulder, and the disease is liable to spread towards the chest walls under or between the pectoral muscles; it may also travel upwards, and invade the shoulder-joint from sloughing of the capsule, and so give rise to an acute arthritis. Early and extensive incisions are required in order to prevent such complications, care being taken to avoid important vessels and nerves. It is most important in these cases that the arm should be kept away from the side in a fully abducted position so as to guard against later fixation of the arm to the side by contraction of the cicatrix.

Cellulitis of the Scalp usually results from a wound which has penetrated the occipito-frontalis aponeurosis, and reached the subjacent layer of loose areolar tissue; it may, however, follow a simple laceration of the scalp and remain superficial. In the latter case the scalp becomes red, œdematous, and tender, but the inflammation remains more or less localized; in the former, pus forms beneath the aponeurosis, and extends to its limits of attachment, so that abscesses are likely to point in the forehead just above the eyebrows, over the zygoma, or along the superior curved line of the occipital bone. The whole scalp may be lifted up, and the patient runs a risk of necrosis of the cranial bones and of various intracranial complications The scalp itself, however, rarely sloughs owing to its abundant vascular supply. The *treatment* consists in making early and free incisions parallel to the lines of the vessels.

Cellulitis of the Orbit is not an uncommon sequel of penetrating wounds in this region, owing to the difficulty of disinfecting and draining them. It may also be secondary to suppuration within the cranial sinuses. The orbital tissues become infiltrated and swollen, the eyelids œdematous, and the eyeball pushed forwards (proptosis). The inflammation may spread directly to the meninges, or through the veins to the cavernous sinus Necrosis of the orbital walls may also occur, whilst the eye itself may suffer, either from an infective panophthalmitis due to lymphatic infection, or from optic neuritis secondary to retro-ocular inflammation and pressure, or, at a later period, from optic-nerve atrophy secondary to cicatricial contraction around the nerve. If the cellular tissue of the orbit sloughs, the subsequent movements of the globe may be much hampered, or indeed lost, whilst the lids may be drawn back to such an extent as to prevent their complete closure.

Treatment.—No penetrating wound of the orbit ought to be closed if there is any question of its infection; indeed, it is often wise to increase its size slightly, so as to enable the deeper parts to be cleansed and drained. If cellulitis follows, the original wound must be opened up, and possibly fresh incisions made either through the lids or through the fornix conjunctivæ. Fomentations are then applied. If panophthalmitis supervenes, the eyeball must be incised crucially; this is a safer proceeding than enucleation, which is more liable to be followed by meningitis.

Cellulitis of the Neck is usually secondary to lesions in the throat, and therefore associated with follicular tonsillitis, diphtheria, or scarlatina, the process probably starting in a deep lymphatic gland; it occasionally follows operations on the neck, or may be due to suppuration in the mastoid cells. If the infection is beneath the deep cervical fascia, the affected side of the neck becomes swollen, red, and brawny; severe pain of a deep tensive character is experienced, and this is increased by movements of the head or jaw. The swelling is often peculiarly hard and resistant, and, although œdema may be present, it may be several days before the surgeon can detect any focus of softening suggestive of suppuration. During this period the constitutional symptoms are severe; fever may be high, and the pain and consequent sleeplessness may exhaust the patient, whilst the difficulty of swallowing hinders

nutrition. Dangerous symptoms arise from pressure on important vessels and nerves, from extension of the inflammation to the mediastinum or to the glottis, causing œdema and consequent dyspnœa, or from the supervention of pyæmia owing to venous thrombosis. The process usually ends in sloughing of the cellular tissue and suppuration, the pus burrowing widely if a free exit by incisions through the deep fascia is not provided.

Treatment.—The causal lesion in the throat must be attended to, any operation wound freely opened up and drained, and the general condition improved by the administration of nourishing fluid food, stimulants, and quinine. Antistreptococcal serum may also be injected, but sometimes anti-diphtheritic serum has been found equally useful; immuno-transfusion may also help. Locally, fomentations are applied in the first place; but on the onset of suppuration, or before, if the pressure symptoms are severe, or if the affection is obviously extending, free incisions must be made along lines of safety through the deep fascia, so as to relieve tension and give exit to discharges. It must be remembered that the tissues are matted together in such a way as to render their recognition difficult; and inasmuch as the pus often lies deeply, the greatest caution has to be taken to avoid injury of important structures.

Special interest has been directed to a form of this affection which occurs in the submaxillary region, and is known as Ludwig's angina. It is usually secondary to some buccal focus, or may occasionally result from the extension of inflammation through the capsule of lymphatic glands, or may originate in disease of the middle ear, the mischief spreading down along the posterior belly of the digastric. The swelling in these cases extends forwards beneath the chin, and may involve the floor of the mouth and base of the tongue, pushing that organ forwards, and even making it protrude from the mouth. Œdema of the glottis may supervene, or a sublingual abscess form. Treatment is similar to that indicated above, and one or more incisions may be required. Œdema of the glottis will probably require tracheotomy.

Pelvic Cellulitis is an infective inflammation of the loose cellular tissue which ensheaths the pelvic viscera. It may result from any penetrating wound, accidental or operative, which encroaches on this region—*e.g.*, extra-peritoneal rupture or perforation of the bladder, suprapubic or lateral lithotomy, injudicious catheterization, curetting the uterus, and sometimes attempts to induce abortion. It may also be due to the spread of bacteria from any of the pelvic viscera—*e.g.*, the bladder, prostate, rectum, uterus, or Fallopian tube. It is associated with all the local and general signs of deep inflammation, and often, indeed, with peritonitis, giving rise to a tense, firm, painful swelling, to be felt *per rectum* or *per vaginam*, and sometimes to an indurated mass of inflammatory effusion, dull on percussion, above the pubic arch. Abscesses may form, bursting either externally above Poupart's ligament or into some of the viscera, or possibly in both directions, producing intractable forms of urinary or fæcal fistulæ, whilst venous thrombosis and pyæmia from the breaking down and dissemination of the infected blood-clot are likely to develop.

The surgeon may be called in to such cases in the early pre-suppurative stage, when rest, limitation of diet, small doses of opium, and fomentations to the hypogastrium, with hot rectal or vaginal douches, should be adopted. At a later date, when pus has formed and the abscesses need to be opened, an incision is generally made just above Poupart's ligament and close to the pubic spine; the abdominal muscles are divided to a sufficient extent to enable the surgeon to work downwards between the transversalis fascia and the peritoneum, which must be pushed aside in order to reach the broad ligament, where pus is frequently found. As soon as the subperitoneal tissue is opened, the knife should be discarded, and only blunt instruments or the fingers employed. The cavity of the abscess should be efficiently drained, and for this a counter-opening through the vagina may be required.

Intestinal obstruction may develop as a remote sequel from the contraction of cicatrices, and hydronephrosis may arise in the same way from pressure on the ureter.

IV. **Wound Infection.**

When a wound, whether accidental or operative, has become infected with micro-organisms, healthy reparative action ceases, and is replaced by an inflammatory process of a suppurative type. In accident cases, wound infection is often unavoidable, and due to the dirty state of the skin or the nature of the accident; and, however thorough the subsequent disinfection, it may be impossible to render the parts sterile. Still more does this hold good in military surgery. In operative work wound infection in a previously non-septic case is usually due to some avoidable mistake or oversight, only occasionally to auto-infection. Ineffective sterilization of silk or catgut is perhaps the most frequent cause, since the introduction of rubber gloves has largely safeguarded the patient from infection from the hands of the surgeon and his assistants. Devitalization of the tissues as a result of rough handling or prolonged exposure is, however, an important predisposing element. The organisms present are exceedingly variable, as might be expected. In post-operative cases, staphylococci are usually found, but in the worst cases streptococci occur, and possibly a mixed infection. In casualty and still more in military work a mixed infection is generally present, often including anaërobes, as well as the above.

The **local** trouble may manifest itself merely as an acute or subacute suppurative process within the wound, or as an active cellulitis spreading into the adjacent tissues.

In post-operative cases it may commence deeply around a buried stitch, or more superficially. In the latter case the lips of the wound look red and puffy, the tissues often swell up between the stitches, which look as if they had become too tight, and on introducing a probe pus may escape; the patient complains of pain, usually of a throbbing nature, and there is some rise of temperature, and in bad cases even a rigor. In the milder forms, the changes are limited to the immediate neighbourhood of the wound; but, if neglected, or in an unhealthy subject, or if due to virulent organisms, the phenomena of an acute cellulitis may supervene.

When the process starts in the deeper parts of the wound, nothing may be obvious for a few days, except perhaps some fulness and tenderness on pressure, together with some slight rise of temperature. Sooner or later an abscess develops and comes to the surface, and a sinus is likely to be left until the offending material, *e.g.* a ligature or buried stitch, has been absorbed or removed. The same holds good as regards silver wire, screws, plates, etc., which must be removed before healing can take place.

Cases due to accident are often seriously complicated by the carrying in of infected material, such as portions of the patient's clothing, soil from the road, dirt or grease in machinery accidents, etc., and the bacteria derived therefrom, or from the patient's skin, find an abundance of suitable material for their development in the torn and damaged tissues. The results of such contamination

necessarily vary with the depth to which the lesion has extended, and may consist of sloughing of and suppuration in and amongst the various structures affected. Pus tends to track and burrow along opened-up planes of tissue, and the swelling of the more superficial parts aggravates the condition by hindering mechanically the escape of discharge from the deeper parts.

The **General Phenomena** connected with wound infection vary chiefly with the nature and virulence of the infecting organisms, whether these produce active toxins, and whether or not the blood itself becomes invaded.

1. **Toxæmia.**—**Acute Toxæmia** (formerly known as **septic traumatic fever**) results from the absorption of a large dose of toxic material from some focus of infective inflammation of sufficient extent and virulence. A small collection of pus under pressure is capable of giving rise to marked toxic symptoms, whilst in spreading inflammations, such as erysipelas and cellulitis, the manifestations are often of a grave type. The same is true of infective inflammation of the peritoneal cavity, especially when the upper half is involved, since the communication with the lymphatics of the diaphragm is very free. Toxæmia is not infrequently associated with a true septicæmia, and clinically it may be almost impossible to distinguish between the two.

The **Symptoms** are fever (except in some of the gravest cases, when the temperature may be subnormal, although the pulse may still remain high), accompanying loss of appetite, a dry tongue, a quick pulse rapidly becoming weak, severe headache, and nocturnal delirium of some intensity. The patient is at first constipated, but vomiting and diarrhœa may ensue from gastro-intestinal irritation, followed by exhaustion, collapse and death, or he may become comatose for some time before death, according to whether the toxins act principally upon the alimentary or nervous system. Dyspnœa from pulmonary congestion, and albuminuria, also occur. Effective treatment of the cause, as by opening an abscess or drainage, may lead to a speedy disappearance of the symptoms, but in spreading inflammation the toxæmia may not subside for some time. Should an attack prove fatal, the post-mortem manifestations are practically identical with those seen in septicæmia, but the blood is free from infective bacteria.

Chronic Toxæmia is produced when toxins are absorbed from a local focus for a considerable time. The conditions which result from a septic psoas abscess are a typical illustration of this, and if allowed to persist the syndrome of hectic fever (p. 75) will sooner or later develop.

2. **Septicæmia.**—Should the organisms not only develop in the tissues, but also find their way into the blood, Septicæmia results (p. 94), but the line of demarcation between it and acute toxæmia in individual cases is not easily established.

3. **Pyæmia.**—Bacteria may escape into the blood, not only as detached invaders which subsequently multiply within it, but occasionally in the form of colonies of some size, carried perchance

in a fragment of disintegrated blood-clot. Such an embolus is disseminated in the blood-stream, and wherever it lodges a secondary abscess is likely to develop. This condition is known as Pyæmia (p. 98), and these abscesses may thus be found in a patient who also shows obvious signs of acute toxæmia.

The **Local Treatment** of an infected wound necessarily varies with the length of time which has elapsed since the infection and with the conditions present.

In a mild post-operative infection the relief of tension and the application of warmth and moisture to the part to encourage the local reparative activity of the tissues usually suffice. Stitches, both superficial and deep, must be immediately removed, and the wound widely opened up so as to give free exit to the discharge. Undue interference, as by scraping, squeezing, syringing, etc., is to be deprecated, as thereby the infection may be disseminated. It is futile to apply strong antiseptics, since the organisms have penetrated into the tissues and cannot be destroyed without also involving these structures; moreover, the phagocytic power of the leucocytes is thereby checked. Some of the more modern antiseptics, such as the hypochlorites or flavine, are less objectionable and may be useful on occasion; but it is possible that the benefits which follow their judicious employment are due to causes other than their antiseptic qualities.

Sloughs may be cut away, but generally are left to separate by natural processes, assisted perhaps by the use of hypertonic substances, such as gauze soaked in salt solution (5 per cent.), or glycerine and iodoform (10 per cent. emulsion). If there is a considerable cavity in the depth of the wound, it may be desirable to drain it by introducing a strip of sterilized rubber glove or a rubber drainage-tube. Otherwise the wound is lightly packed, and warm moist applications, *e.g.* boracic fomentations, are applied. At the same time the bowels must be freely opened, and the general health of the patient carefully watched. In a few days, when granulations have formed, the wound may be irrigated with normal salt solution or swabbed out with peroxide of hydrogen. Healing is finally brought about by granulation, but can sometimes be hastened by strapping the edges of the wound together, or by grafting.

If such a régime does not suffice to stop the process, the wound must be still further opened, and the spreading infection followed up —in fact, it is treated as a cellulitis. Sometimes great benefit is derived from the use of a poultice made of linseed meal and boiling boric acid lotion, placed between layers of cyanide gauze; this type of poultice is aseptic, and retains its heat better than a fomentation, whilst it is softer and adapts itself more readily to irregularities of surface. In other cases the Carrel-Dakin treatment (p. 88) may be instituted.

In the graver cases of traumatism associated with infection, whether occurring in civilian or military surgical work, more active

and energetic measures have to be taken in order to prevent, if possible, the very serious results which are likely to supervene.

The **immediate** treatment of a gravely infected wound is governed entirely by the length of time which has elapsed since its infliction. It has been abundantly proved that for a period of eight to twelve hours bacteria do not penetrate deeply into the tissues. Presumably they are establishing their hold, and the limited number primarily admitted take some time to multiply. Hence within twelve to twenty-four hours of its infliction there is good hope of effecting complete sterilization of the wound by vigorous mechanical or chemical means.

Early Attempt to sterilize a Wound.—The patient is anæsthetized, and the clothing removed. Hæmostasis is effected, and the wound cavity temporarily packed with gauze soaked in some suitable antiseptic (*e.g.*, carbolic lotion 1 in 20, Dakin's solution, a strong solution of brilliant green, or any other that the surgeon favours), and the surrounding skin shaved, cleansed, and purified. In very dirty cases it may be desirable to begin with turpentine, and then to wash the skin with an ethereal solution of soap, finally employing either Lister's strong mixture or an alcoholic solution of biniodide of mercury, but other solutions may be equally well utilized. The wound itself is then uncovered and investigated.

The bruised and torn margins of the wound are excised, as also all dead and damaged deeper tissues. Muscle tissue is carefully examined, especially in street accidents or gunshot lesions, as gas gangrene may develop therein. The exposed fibres are cut away until healthy vascular tissue which reacts quickly to pinching lightly with forceps is reached. Anti-gas-gangrene serum should be given in all such cases. Foreign bodies and dirt are of course removed, and the skin wound is enlarged along lines of safety in order to expose the deeper parts.

If the surgeon is satisfied with the appearance of the tissues thus laid bare, he may proceed to close the wound by **Primary Suture,** with or without the application of such diffusible antiseptics as ether or spirit (possibly in combination with biniodide of mercury, 1 in 500). Other surgeons prefer to protect the tissues by rubbing in B.I.P.P. (p. 90) after cleansing with alcohol. Closure is best effected by through-and-through silkworm-gut sutures; it may be advisable to make some provision for drainage.

If the surgeon is doubtful as to the condition of the wound, it is wise not to close it at once, but to pack the cavity with gauze soaked in flavine (1 in 1,000), or impregnated with B.I.P.P., or to treat it by the Carrel-Dakin method. If at the end of two or three days the wound is practically sterile, or the discharge therefrom contains only a few bacteria, **Delayed Primary Suture** may be undertaken. A bacteriological examination of the discharge is most important, particularly with a view to determining whether or not streptococci, especially if of hæmolytic type, are present, as, if this be so, it is useless and dangerous to attempt suture.

If at the end of two or three days the infective process is active and numberless bacteria are present, then treatment as for cellulitis by one or other of the methods indicated below must be carried out; and healing occurs by granulation, assisted perhaps by grafting, or hastened by late **Secondary Suture.**

The treatment of broken bones is not alluded to here, but if present they must be dealt with in accordance with the plans outlined in Chapter XX. Of course, where the tissues have been in contact with road dirt or soil, it is wise to protect the patient from tetanus by the administration of prophylactic doses of antitetanic serum.

The **Carrel-Dakin treatment of wounds** is dependent on the antiseptic properties of the hypochlorites, especially of Dakin's solution, which destroy bacteria, but do no serious damage to the phagocytic activity of the leucocytes or to the reparative power of the tissues. The essential is to open up and cleanse all the depths of an infected wound; dead and badly damaged tissues are removed, but it is not always necessary to provide dependent drainage, and indeed the wound which can be most readily treated by this method is one which can be kept full of the solution. Multiple tubes with a calibre of 4 mm. and 30 cm. long are then introduced so as to command all the depths of the wound, entering into all pockets, and they are kept in place by strips of gauze soaked in Dakin's solution placed amongst them, and between them and the walls of the cavity. These tubes are closed at one end, but perforated for a variable distance by minute apertures (Fig. 22); in a large wound it is possible that six, eight, or even twelve such tubes may be required. Their free ends are gathered up by glass connections (two- or four-fold) which link them by larger tubes to one or more reservoirs above the bed, from which a limited quantity of Dakin's solution is allowed to escape every two hours so as to irrigate the wound. If no reservoir is available, a syringeful of the antiseptic is squirted down the main tube; a clip is subsequently placed on this tube so as to prevent regurgitation, and thereby ensure the escape of the fluid through the tiny perforations into the depths of the wound. The tubes pass out from the wound between layers of gauze, soaked in the solution, which cover it, and through a sheet of sterilized non-absorbent wool in a gauze cover. The Dakin's solution is sometimes irritating to the skin, especially if free alkali is present, and to prevent this the parts around the wound should be protected by layers of gauze infiltrated with sterilized vaseline. The amount introduced two-hourly need not be great, but provision has to be made to prevent the bedding from getting wet, as the solution has a damaging effect on bed-linen. When the healing is progressing satisfactorily, and secondary suture is not to be undertaken, a chloramine ointment is useful; it should consist of chloramine-T, 10 parts; stearate of soda, 86 parts; and water, 4 parts.

When properly carried out, this treatment is most valuable, but

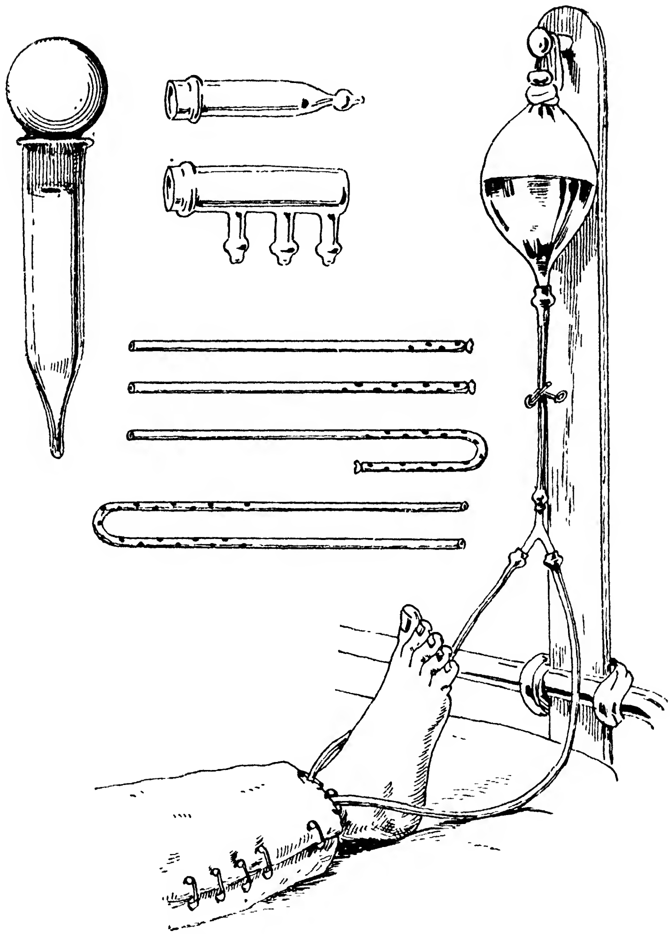


FIG. 22.—APPARATUS REQUIRED FOR STERILIZATION OF WOUNDS BY THE CARREL-DAKIN METHOD.

To the right is seen the flask or other container suspended at the end of the bed, and from it descends a rubber tube commanded by a clip; it divides below into two branches which pass in beneath the external gauze and wool dressing to the wound.

In the centre above are represented the glass connections for the special rubber tubes. 1-tube and 3-tube connections are shown; others are available with 2 and 4 branches. Below this are seen the rubber tubes with tiny holes punched in them to a distance corresponding to the depth and extent of the wound; the ends of these tubes are tied.

In the left corner is the syringe which may be used where no suitable container is available. The stopper is of rubber and connected above with a rubber ball.

it requires very careful organization of technique and efficient assistance. The bacterial content of the discharge from the wound is tested from time to time, and as the hypochlorite becomes effective, the number gradually diminishes until in ten to fourteen days, perhaps, only one bacterium is found in several microscopic fields of the smear. The wound is then regarded as clinically sterile, and secondary suture may be adopted. The absence of fever and toxæmia is very marked, the patient's sufferings are much reduced, the amount of reactionary injury to deeper tissues is minimized, and hence repair is more rapid and accompanied by less mutilating disabilities and disfigurements than under other circumstances. The opportunity of undertaking secondary operations on damaged nerves or bones at an early period is of great value.

It is but just to point out that Sir A. Wright casts doubt on the value of the solution employed as an antiseptic in the presence of the tissues, and suggests that the good results (which cannot be denied) are to be explained in other ways, *e.g.* the thorough opening up of the wound and the provision of effective drainage; it also introduces the element of repeated irrigation, and involves the continuous personal supervision and care of skilled helpers; and the fluid itself is stated to be hypertonic in its influence.

The **B.I.P.P.** (Bismuth - Iodoform - Paraffin - Paste) **treatment** introduced by Professor Rutherford Morison is simple and valuable. It consists in opening up and cleansing the wound mechanically by excision of damaged tissues or friction with gauze swabs. Complete hæmostasis must be secured, and the wound is then dried with ether or alcohol. The surface is rubbed over with swabs, covered with an antiseptic paste, consisting of bismuth carbonate, 1 part; iodoform, 2 parts; and sufficient liquid paraffin to make the paste the consistency of clotted cream. In preparing the paste, each element must be previously sterilized, the iodoform by washing with 1 in 20 carbolic lotion, the bismuth and paraffin by dry heat at a temperature of 120° C. for half an hour. The bismuth and iodoform are mixed in a sterile mortar, and the paraffin is slowly added and well stirred, so that no lumps or gritty masses occur. The B.I.P.P. should be carefully though thoroughly applied to the surface of the wound, being gently rubbed in with a sterilized swab, especially into the muscles, so that a thin film covers all the tissues; lumps of the paste must not be left in the depth of the wound, and no undue quantity must be employed for fear of toxic symptoms; a drachm is usually quite sufficient even for a large cavity. If the wound shows no tendency to ooze and otherwise appears to be favourable, complete suture without drainage may be adopted. In less favourable conditions the wound is left open and packed with sterile gauze; unless any special cause for re-dressing supervenes, the wound is left for five or six days; on removing the gauze the wound looks very dirty, being covered with a mixture of pus and paste, but on washing this away with sterile salt solution, the surface should now appear healthy, and granulations be found

beginning to form. A similar dressing is reapplied, and may often be left for another period of five or six days, when reparative activity should be fully established.

Secondary suture is often possible in these cases; the skin around is thoroughly cleansed, and the margins excised and undercut for a short way. The granulations are freely curetted; bleeding is stopped completely; the surface is dried by ether or alcohol, and carefully 'bipped'; sutures are introduced, buried ones of catgut to close muscular gaps, and deep ones of silk or silkworm gut to command the main wound, whilst fine catgut stitches bring the margins of the skin into accurate coaptation.

B.I.P.P. is also extremely useful in wounds made through healthy tissues in order to remove sequestra or drain infected cavities. After drying the parts, the paste is well rubbed into the tissues, and thereby spread to them of infection from those parts already infected is prevented. In chiselling away living bone in order to expose sequestra the likelihood of infecting the bone is very great, and the use of B.I.P.P. to protect the exposed bony cancelli is most advantageous. In re-amputations also, especially when granulating areas are present, B.I.P.P. will usually protect the tissues divided, and permits the surgeon to close the wound with good prospects of securing rapid healing.

Toxic symptoms have occurred as the result of the employment of this agent, and mainly in the direction of bismuth poisoning. A brilliant blue discoloration of the gums occurs, which may also appear on the mucous membrane of the cheeks and tongue. Occasionally gastro-intestinal disturbances arise in the form of colic and diarrhœa, and a few fatal cases have occurred; ulceration and sloughing of the sigmoid have been found in some of these. Care must also be taken that the paraffin is pure; some cases of irritation around the margins of the wound have been traced to imperfectly refined paraffin.

Finally, it must be pointed out that the presence of this paste in the wound interferes with X-ray examinations, since bismuth casts a shadow, and that excess of the paste may lead to a persistent sinus or even to a secondary abscess which can heal only when the excess of paste has been discharged.

Flavine (p. 289) in a solution of 1 in 1,000 has been recommended by Browning and others, who claim that its antiseptic powers are enhanced by the presence of blood-serum (which hinders the action of the hypochlorites), that it has no deleterious effect on phagocytosis or tissue activity, that it is a stable non-toxic compound, and that its effects in a septic wound are most marked when gauze soaked in a solution of the dye is kept in close and persistent contact with the tissues. Bacteria are said to be quickly destroyed and wound sterilization is rapidly accomplished. Most observers do not agree with these claims, but maintain that, whilst the secretion of pus is checked or aborted, the process of repair is also delayed and the growth of epithelium hindered, so that, at the end of a week, although

there may be no pus in the wound, yet the surface looks much as it did at the start; after a time a yellowish film or pellicle forms in which the superficial layers of the exposed tissues are incorporated, and the wound takes on the appearance of a callous ulcer. If now the flavine is discontinued and other applications, such as normal salt solution or eusol, are substituted, the wound as a rule quickly assumes a healthy aspect. It is obvious that flavine has beneficial powers, but it is possible that we have not yet ascertained how best to use it.

Sir Almroth Wright's Physiological Method of treating Wounds was introduced during the late war in order to combat the serious consequences which followed the break-down of the ordinary aseptic and antiseptic measures for dealing with wounds, found sufficient in civilian work. It is probable that this resulted rather from the half-hearted application of Lister's principles than from any fallacy in the Listerian principles or practice themselves. Sir A. Wright attacked the problem from the laboratory standpoint, and observed that the surface of a freshly inflicted gunshot wound is in the main non-vascular, since the tissues penetrated are killed, and that the lymphatic spaces are open; there is thus no protection available, except from the leucocytes which emigrate and the lymph which exudes. Upon this is grafted a bacterial invasion often of a very virulent type. The bacteria find an abundance of suitable pabulum and usually multiply at an alarming rate, spreading widely into the damaged tissues, and causing extensive inflammation. The delay often experienced in bringing the wounded man under treatment of course allows extension of the infection.

The main difficulties in the treatment of such wounds are: (1) That the germs spread so rapidly and deeply that their effective removal by surgical measures is often an impossibility without the most serious sacrifice of useful tissues: (2) That the invaded tissues are infiltrated and brawny, the capillary circulation being hindered by the perivascular pressure of effused lymph; in other words, the wound is 'lymph-bound,' and there is but little discharge: (3) That any lymph which escapes into the wound is stale and has lost its active antibacterial properties, or is vitiated by the presence of trypsin arising from the breaking down of leucocytes, and trypsinized serum is an excellent pabulum for bacteria; hence the very efforts of Nature to cope with the infection appear to favour its development unless carefully controlled and directed: (4) The presence of adherent sloughs provides persistent cover for fresh bacterial activity. If these sloughs cannot be removed by surgical intervention, they have to be separated by a natural process, which practically consists in their complete or partial digestion by the trypsin set free in the discharges. This erosive digestion, whilst it is useful in the removal of dead structures, may also spread into living tissues, causing secondary hæmorrhage.

The chief means of cure when such an infection has once developed reside: (1) In the lymph, which when fresh has decided antibacterial

properties and also considerable antitryptic power; this latter increases rapidly in an infected man, but is lost if the lymph becomes 'stale': (2) In the leucocytes with their phagocytic powers, bringing to an end bacterial activity, and thereby encouraging reparative changes in (3) the tissues, which, when once the bacteria are seriously weakened, assert their natural tendency to repair.

The agent recommended by Wright for counteracting the evil influences at work in the wound and for stimulating the reparative activities is a solution of chloride of sodium, either hypertonic or isotonic.* Hypertonic salt solution (5 or 10 per cent.) acts beneficially in several directions: (1) It encourages lymph drainage of the tissues, and thereby not only removes stale lymph and replaces it by fresh and active lymph, but also restores the vascular supply of the tissues by modifying the lymph-bound condition of the parts. (2) It also limits leucocytic emigration and therefore reduces the amount of pus secreted. (3) It disintegrates any leucocytes with which it is brought in contact, and sets free a limited amount of trypsin in the wound which can act upon the sloughs and loosen them by erosive digestion; this power is held in check by the antitryptic influence of healthy lymph. From these facts it is obvious that hypertonic salt solution will be of most value in the treatment of the earlier stages of an infected wound. There comes a time when its beneficial influence is lost, and indeed it may be positively harmful, and then the surgeon may wisely employ the isotonic or normal salt solution (0·85 per cent.), which attracts leucocytes and favours phagocytosis.

The value of the application of hypertonic solutions to infected wounds cannot be denied, but it is not only the sodium chloride solution which thus acts beneficially. Other agents, such as glycerine, as in the old-fashioned iodoform emulsion (10 per cent.), and perhaps Dakin's solution, act mainly in this way. It must be admitted, however, that some surgeons attribute these benefits not to the osmotic action, but to the continued moisture, which loosens any dried clot or lymph on the surface, and permits a more abundant flow of lymph from the tissues.

The method of application of hypertonic solutions varies widely with the character of the wounds. In accessible superficial lesions all that is needed is to apply to the surface moderately thick

* The influence upon the tissues of various fluids brought into contact with them differs with their specific gravity and density, and may be illustrated by the effect on red blood-cells of varying strengths of salt solution An isotonic solution (0·85 per cent.) has no osmotic pressure on either side, and the red cells remain unharmed. A hypertonic solution (5 per cent.) exercises considerable osmotic pressure towards the solution, and fluid is withdrawn from the red cells, which become shrunken and crenated. A hypotonic solution allows the cells to absorb fluid to such an extent that they swell up and burst, and thus the injurious influence of plain water on the tissues is in part explained. It is only necessary to irrigate the nasal fossæ firstly with normal salt solution which is comforting, and then with plain warm water, to appreciate the irritating influence of the latter agent on the tissues.

pads of sterilized lint or gauze soaked in the solution, and keep them covered with a layer of jaconet. This dressing is renewed frequently. In other cases where repeated dressing may do harm, the lint or gauze is kept moist by allowing the solution to drop on to it from a suitable reservoir. In deep wounds the solution may be carried into the deeper parts by tubes and allowed to escape from the wound on the Carrel system.

Wounds treated in this fashion rapidly take on a characteristic appearance. They become clean, of a pink colour, and are covered by an exceedingly thin layer of granulation tissue from which little or no pus is discharged. The organisms, too, are greatly reduced in numbers. Such wounds heal slowly, if at all, unless the hypertonic is replaced by normal saline solution, and then the surface of the wound becomes grayish and discharges a considerable amount of pus, but granulation quickly occurs and healing goes on satisfactorily.

It must not be forgotten that Wright himself admits that dead spaces in the tissues—*i.e.*, spaces in which pus can collect—must be effectively opened up and drained before any good can follow the use of hypertonic salt solution, and it is not improbable that much of the value of his method depends on suitable removal of dead tissues and effective mechanical drainage of the wound, and these have long been recognized as constituting the essential elements in the treatment of infected wounds.

V. **Septicæmia.**

Septicæmia is the condition of infection of the blood by bacteria and their proliferation therein. It differs from pyæmia in the absence of secondary abscesses (although, as explained later, it may be associated with it), and from toxæmia by the fact that the latter is merely due to the absorption into the blood of toxins generated in a diseased focus in which the bacteria themselves remain localized. In other cases, again, the process is rather that of an overflow phenomenon, in which the organisms gain access to the blood-stream from some septic focus, but do not proliferate in the blood itself—a condition to which the term **bacteræmia** is now applied. In both septicæmia and bacteræmia the organisms circulate in the blood, though in many cases, especially of bacteræmia, in but scanty numbers, and periods may occur in which no bacteria can be detected in the blood, so that too much weight should not be attached to a single negative bacteriological result.

Bacteriology.—The commonest organisms are undoubtedly streptococci (p. 61), which are almost always present in puerperal septicæmia and in ulcerative endocarditis. Next in frequency is the *Pneumococcus*. The *Staphylococcus pyogenes* is also a fairly common organism in this condition, and the prognosis is then less grave.

PLATE VI.

FIG. 1.—TREPONEMA PALLIDUM (SPIROCHÆTA PALLIDA) IN SCRAPING FROM HARD CHANCRE, SHOWN UNDER DARK-GROUND ILLUMINATION, ALONG WITH SEVERAL RED BLOOD-CORPUSCLES AND SOME STAPHYLOCOCCI.

(× 1000.)

FIG. 2.—TREPONEMA PALLIDUM (SPIROCHÆTA PALLIDA) IN SECTION OF LIVER FROM CASE OF CONGENITAL SYPHILIS.

(Stained by Levaditi's Silver Impregnation Method, × 1000.)

FIG. 3.—TUBERCLE BACILLI IN FILM OF SPUTUM FROM CASE OF CHRONIC PHTHISIS.

The acid-proof tubercle bacilli are stained red, other organisms of secondary infection blue. (Ziehl-Nielsen Method, × 1000.)

FIG. 4.—TUBERCULOSIS OF SYNOVIAL MEMBRANE OF KNEE-JOINT.

Section showing part of a 'giant-cell system,' showing central giant-cell, endothelioid, and small lymphocyte-like cells, and tubercle bacilli. (Ziehl-Nielsen Method, × 500.)

FIG. 5.—TUBERCLE BACILLI IN FILM OF CENTRIFUGALIZED DEPOSIT OF CEREBROSPINAL FLUID FROM CASE OF ACUTE TUBERCULOUS MENINGITIS.

Small lymphocyte-like cells, polymorphs and an endothelial cell are shown. (Ziehl-Nielsen Method, × 1000.)

FIG. 6.—LEPROSY BACILLI, MOSTLY WITHIN THE 'LEPRA-CELLS' IN A SECTION OF SUBCUTANEOUS LEPROUS GRANULATION-TISSUE.

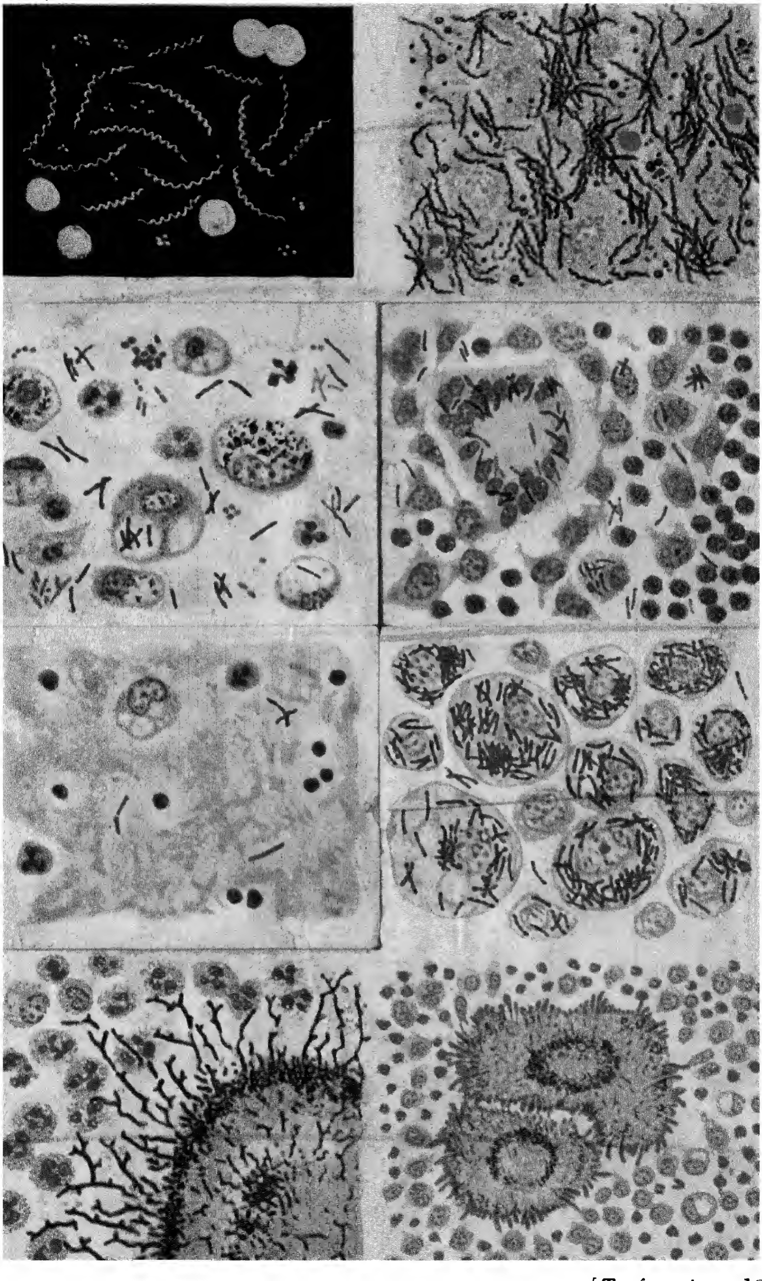
These cells are analogous to the 'endothelioid cells' of tuberculosis. (Modified Ziehl-Nielsen Method, × 1000.)

FIG. 7.—STREPTOTHRIX ACTINOMYCES, IN SECTION OF HUMAN LIVER-ABSCESS, SHOWING BRANCHING GRAM-POSITIVE FILAMENTS AT PERIPHERY OF COLONY RADIATING OUT AMONG PUS-CELLS: BACILLARY AND COCCOID FORMS, AND AMORPHOUS CENTRE. (Gram's Stain, × 500.)

FIG. 8.—STREPTOTHRIX ACTINOMYCES IN SECTION OF 'WOODY TONGUE' OF COW, SHOWING TWO COLONIES WITH 'CLUBBING' OF THE SHEATHS OF THE FILAMENTS AT THE PERIPHERY, CENTRAL DEGENERATION WITH COMMENCING CALCIFICATION, AND SURROUNDING GRANULATION-TISSUE WITH ENDOTHELOID CELLS AND POLYMORPHS.

(Gram's Stain, × 300.)

PLATE VI



[*To face page* 188

Rarer causes are *B. coli* and allied organisms, *B. pyocyaneus*, and the *Gonococcus*. It may also be noted that the specific organisms of certain of the acute infective fevers, *e.g.* typhoid and paratyphoid, may be found in the blood, especially in the earlier stage of these infections; whilst the septicæmic forms of anthrax and plague are conditions of the utmost gravity and often prove fatal.

Clinical History.—Septicæmia occurs most commonly from direct inoculation with virulent streptococci through small lesions, such as post-mortem wounds, or from scratches or punctures with infected pins or instruments; in rarer cases it follows operation wounds and severe lacerated injuries. It is the usual accompaniment or sequel of acute spreading gangrene, and may be met with in cellulitis and cancrum oris. As a rule the individual attacked is in a debilitated condition, perhaps from overwork, or from alcoholic or other excesses, so that the inherent germicidal activity of the tissues is insufficient to cope with the inroads of the disease.

The **Local Changes** at the site of inoculation may be very slight, or may take the form of an acute lymphangitis, or some type of cellulitis or spreading suppuration, or even an acute spreading gangrene.

The **General Symptoms** are those of fever, often ushered in by a distinct and severe rigor; the temperature reaches 104° or 105° F. and usually remains high, with but slight remissions and no intermissions (Fig. 23). Malaise is present, with loss of appetite, and the tongue is brown and parched. The pulse is quick and feeble, the heart-sounds are weak, and the heart itself dilated. The skin has often a slight icteric tinge, and petechiæ are present. Diarrhœa usually ensues, and the fæces may be blood-stained, whilst the urine is albuminous and contains blood. The patient may, after a period of delirium, become comatose, and die. Dyspnœa sometimes precedes such fatal issue, whilst the temperature may be exceedingly high, or occasionally subnormal; the association of a low temperature with a very rapid pulse is always of grave import. Leucocytosis is usually present and well marked in the earlier stages, but is absent in the worst cases and towards the fatal issue; even under these circumstances there is a relative increase in the number of polymorphonuclears.

Occasionally a case takes a more favourable course when the local focus of infection has been effectively dealt with, and perhaps suitable serum and vaccine treatment adopted. The temperature falls gradually, and the patient slowly returns to health. The accompanying chart illustrates the temperature in such a case, where the true septicæmia, as demonstrated by a blood-examination, gradually disappeared after the uterus had been effectively curetted and disinfected (Fig. 23). Recovery has also occurred in similar cases after the intravenous injection of eusol.

Post-mortem Appearances.—Decomposition rapidly supervenes, rigor mortis is feeble, and cadaveric lividity well-marked, especially along the lines of the superficial veins and posteriorly. The blood

coagulates imperfectly, and is dark and tarry in colour; if allowed to stand, the serum which separates from the corpuscles is much stained from the breaking up of the red blood-cells (hæmolysis) which occurs in many acute infective cases. This condition explains the amount of cadaveric lividity, and also the post-mortem staining of the endocardium and of the tunica intima of the larger vessels, which is such a marked feature in these cases. Most of the serous cavities contain a certain amount of blood-stained fluid, and under almost all

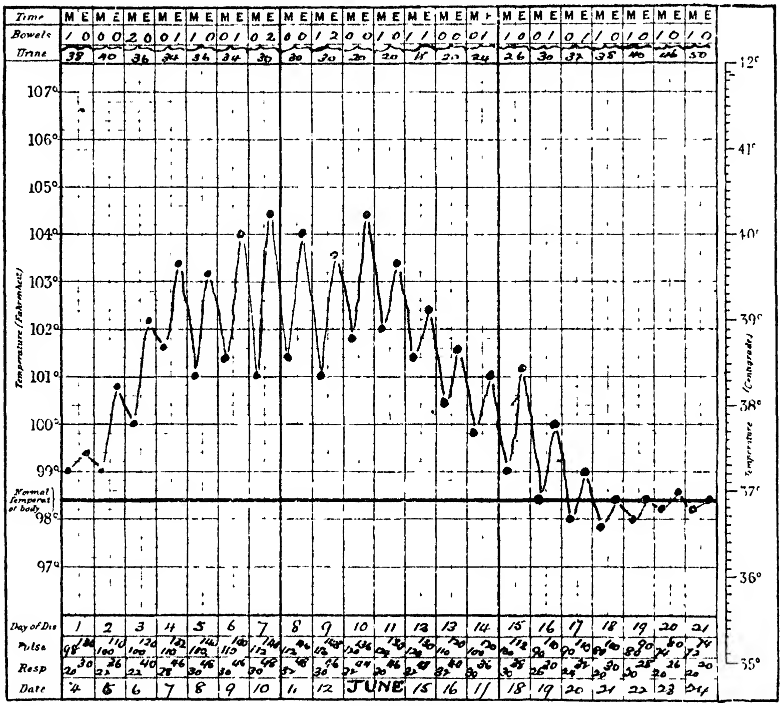


Fig. 23.—Temperature Chart of a Case of Puerperal Septicæmia with Recovery.

the serous membranes are well-marked petechiæ, especially under the pericardium and pleura. The lungs are deeply congested, particularly posteriorly, and very œdematous; the liver, spleen, and kidneys are enlarged, pulpy, soft, and congested, notably the spleen.

Diagnosis.—It is sometimes a matter of considerable difficulty to differentiate cases of septicæmia from those of some of the more virulent forms of the acute exanthemata, before the characteristic appearances are manifested. Acute toxæmia is always associated

with some focus of infection, but may be so severe as to cause grave anxiety for a time as to whether or not septicæmia is present. If, however, the infected area is freely opened up and drained, the rapid disappearance of the fever indicates that the mischief was probably merely a local, and not the more serious general, affection. A blood examination by cultural methods may assist in clearing up the diagnosis. From pyæmia it is known by the absence of repeated rigors and secondary abscesses.

The **Prognosis** of acute septicæmia is always very grave, especially when due to hæmolytic streptococci (chiefly *Streptococcus pyogenes*).

The **Treatment** consists in dealing actively with any local focus of inflammation, either by free incisions and drainage, hot baths, or amputation, if such seems desirable, but in most cases the time for such treatment has passed when the blood becomes infected. General measures vary with the patient and the symptoms, but as a rule sufficient easily digested food is required, together with abundance of fresh air, and sleep must be secured by opium or other hypnotics. Of drugs, probably arsenic as an organic compound administered hypodermically is as good as any, and possibly intravenous infusion of considerable quantities of saline solution, repeated two or three times a day, will be beneficial by inducing diuresis and perhaps diarrhœa, whereby it is hoped that the organisms and their products may be eliminated. Antistreptococcal serum given intravenously in doses of perhaps 50 c.c. for the first few days may be helpful, and probably the univalent serum made from the *S. hæmolyticus* (*i.e. S. pyogenes*) is the best. As soon as a vaccine can be prepared, it should be employed, but it is possible that better results will be secured by the use of immuno-transfusion (p. 24). Intravenous eusol or mercurochrome have been used with success in some cases.

A more **chronic** variety of **septicæmia** is also recognized, which may last for weeks or months. This is often a subacute ulcerative endocarditis, usually due to some non-hæmolytic type of streptococcus. The history may commence with some localized inflammatory trouble from which the patient has never properly recovered. The temperature becomes of the hectic type, running up 3 or 4 degrees every night, and the fever is associated with profuse nocturnal sweats. Bacteria may be demonstrated in the blood at times. The probable cause is the persistent absorption of organisms into the blood-stream from some localized source of infection—*e.g.*, a hepatic abscess or a suppurating gall-bladder or appendix, or a neglected pyorrhœa alveolaris. The patient's health and strength are gradually lost, and, unless the local focus can be reached and dealt with, death is likely to result. Surgical interference, though dangerous in these debilitated patients, may be essential in order to attack the cause of the mischief. Apart from this, vaccine treatment must be relied on, together with such general measures as shall build up the general health and improve the resistance of the blood and tissues.

VI. Pyæmia.

Pyæmia is a disease characterized by intermittent fever, associated with the formation of multiple abscesses in different parts of the body, arising from the diffusion of pyogenic material, such as infected blood-clot, from some area of local infection.

Bacteriology.—Any pyogenic organism may cause pyæmia, the organism most commonly found being *Streptococcus pyogenes*; but in a few cases *Staphylococcus pyogenes aureus* occurs, and less commonly the *Pneumococcus*, *Gonococcus*, or *B. typhosus* or *paratyphosus*; and, in acute glanders in man, the production of pyæmic abscesses due to *B. mallei* is often a characteristic feature of the disease. Experimentally in animals, the mere injection of bacteria themselves into the circulation is not sufficient to give rise to pyæmia; if they are few in number, a transient pyrexia may supervene, and then the germicidal powers latent in the blood destroy them; but if the dose is large, or the resistance diminished, septicæmia, and not pyæmia, results, unless special conditions are present which determine the formation of embolic abscesses. If the bacteria injected are mixed with material or aggregated into masses such that the organisms are carried on particles too large to pass through the terminal arterioles and capillaries, abscesses are likely to develop wherever they lodge. In human pathology the infective emboli consist of infected particles of disintegrating blood-clot (Fig. 24), or of vegetations from diseased heart-valves.

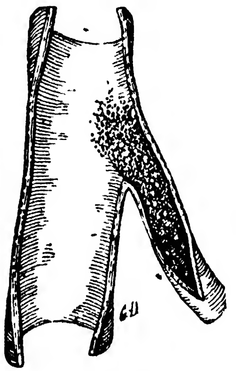


Fig. 24.—Disintegrating Clot lying in a Vein in a Case of Pyæmia.

The apex of the clot projects into a larger trunk, and from this clot infected emboli are easily detached into the circulating blood.

The **Cause** of pyæmia may be stated to be any condition which leads to the formation and detachment of infective emboli in the circulation, such conditions occurring mainly in the veins from disintegration of a thrombus (**infective phlebitis**), but occasionally in the heart (**infective endocarditis**). Acute infective inflammation of the cancellous tissue of bones very commonly leads to the production of pyæmia, owing to the veins being abundant and thin-walled, and considerable tension present from the unyielding condition of the surrounding bony structures. Inflammation of any of the intracranial venous sinuses arising secondarily to diseased bone or spreading in from the exterior may result in pyæmia—*e.g.*, in middle-ear disease, which may result in thrombosis of the lateral sinus. The presence of large open-mouthed veins in the puerperal uterus favours the onset of the disease after parturition if infective material is present in their vicinity.

When an infective embolus lodges in and blocks a vessel in any region of the body, a thrombus forms, and in this the micro-organisms may rapidly develop, the vessel-wall is destroyed, and they spread into the surrounding tissues, causing inflammation, which is likely to end in suppuration. In the lung many such foci may occur, distributed mainly along the posterior border and near the surface; each is sharply limited to a wedge-shaped area of tissue, with the base directed towards the periphery. It is at first reddish in colour from effusion of blood (a **hæmorrhagic infarct**), but soon softens and becomes grayish-yellow from the formation of pus. These abscesses are small, and rarely give rise to any physical signs. Similar collections of pus, preceded or not by infarction, may be found in any organ of the body. The lungs, acting as a filter to emboli derived from the systemic veins, are naturally the first organs to be affected, and from the abscesses formed therein infection of the arterial system may take place, resulting in fresh suppurative foci in the liver, spleen, kidneys, brain, and in or around bones and joints, etc. If, however, the causative phlebitis is situated in the portal area, the emboli become lodged primarily in the liver, giving rise to what is known as **pylephlebitis.** When the emboli are many in number, the symptoms are severe, constituting **acute pyæmia**; this is sometimes associated with a development of micro-organisms in the blood, producing **pyosepticæmia,** the patient perhaps dying before the secondary abscesses have fully developed. In other cases the general symptoms are due rather to the absorption of toxins from the local foci than to the development of organisms in the blood.

Clinical History.—The most marked symptom indicating the onset of **Acute Pyæmia** is the occurrence during a period of febrile disturbance of a severe rigor, which is repeated with a sort of irregular periodicity, most frequently at intervals of about twenty-four to forty-eight hours, somewhat simulating an attack of ague (Fig. 25). The rigors do not differ from those occurring in other diseases, but they are very severe, and usually followed by profuse sweating. Between the rigors the temperature may fall to the normal, but more commonly remains above it. The skin is hot and soon develops an earthy or dull yellow tint, together with erythematous or petechial patches. A sweet, mawkish, hay-like smell of the breath is very characteristic. Symptoms of grave depression supervene, and the patient rapidly wastes. The pulse becomes soft and weak, the excretions are diminished, and a certain amount of nocturnal delirium is noticed, but not necessarily loss of consciousness. The presence of a bruit in the precordial region may suggest the existence of an infective endocarditis, which is not very uncommon. The condition of the tongue varies, but is often red with very prominent papillæ, and becomes dry and brownish. Towards the end of the first week secondary abscesses appear; they are sometimes unaccompanied by local pain or tenderness, and form very rapidly. Joints are not infrequently involved, and may fill with pus, with little or no pain; unless treated early, rapid disorganisation and disloca-

tion may follow. The effusion may be puriform, or thin and oily; it is always, however, swarming with organisms. In the viscera the abscesses are as a rule small and numerous; if they occur in vital organs, such as the heart or brain, death may result from their local development. They are characterized, at first, by the almost total absence of a barrier of granulation tissue, and hence, even when opened early and aseptically, are likely to extend and continue to form pus, instead of following the usual course of rapid repair

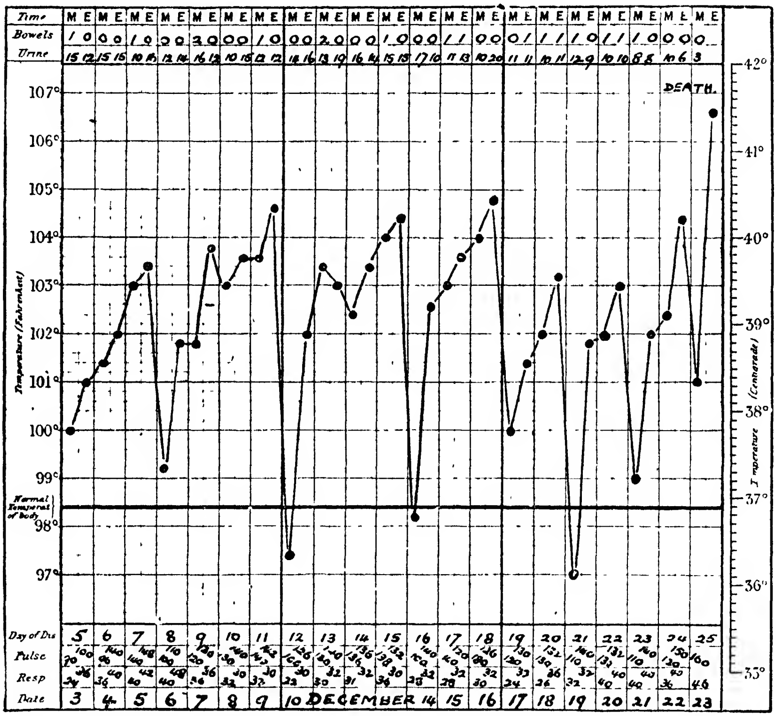


FIG. 25.—TEMPERATURE CHART OF A CASE OF PYÆMIA WHICH TERMINATED IN DEATH.

The peak of each rise of temperature represented a rigor.

which succeeds the aseptic opening of an ordinary acute abscess. Any of the serous sacs, and the meninges, are apt to become involved, and widespread suppuration occur in them.

Not uncommonly in these cases painful patches occur here and there in the subcutaneous tissues, accompanied by hyperæmia, which fades away after a few days. These are probably due to the presence of small infective emboli, which the patient has sufficient vitality to overcome without suppuration.

In **Chronic Pyæmia** the febrile symptoms are much less marked; the abscesses may be few in number, and not dangerous unless forming in important structures.

The condition of an external wound which has given rise to pyæmia may show the following characteristics. It gapes open and presents an inactive, dry, glazed surface, any newly-formed scar-tissue breaking down. A layer of healthy granulations is an almost certain barrier against the occurrence of pyæmia, on account of the germicidal power of its constituent cells. If the disease arises in connection with bone, the latter structure is usually seen lying bare at the bottom of the wound, denuded of its periosteum, and the cancelli filled with sloughy fœtid and disintegrating marrow and pus.

Pathological Anatomy.—The veins leading from the infected area are usually in a state of phlebitis; the coats are thickened, and the lumen is filled with soft, pale, disintegrating clot, which may extend for a considerable distance; the tissues surrounding the vein are also involved in the suppurative process (periphlebitis). Secondary abscesses are found in various parts of the body, most frequently in the lungs, and the consecutive stages in their formation can be clearly demonstrated, from the embolic colonies of bacteria, usually micrococci, through the stage of hæmorrhagic infarction to the complete abscess. The general signs common to all cases of death from toxæmia (p. 95) will also be manifest.

The **Diagnosis** of pyæmia should not be difficult in the majority of cases; but when it originates without any obvious external wound from a deep-seated focus, or if the importance of some local lesion has not been appreciated, the initial symptoms may be mistaken for those of acute rheumatism, malaria or pyelitis.

The **Prognosis** depends upon the inherent vitality of the patient and the virulence of the disease. In acute cases it is extremely grave, probably terminating in a week or ten days, whilst in the chronic type recovery is not only possible, but probable, if the local abscesses are favourably situated.

The **Local Treatment** consists in preventing, if possible, the further contamination of the general blood-stream by the dissemination of infected emboli. This can sometimes be accomplished, in the case of a limb, by amputation well above the local lesion; or if the medullary cavity of a bone is the source, it may be possible to scrape out the gangrenous and offensive medullary tissue, and disinfect the cavity; or if it is due to a wound in the soft parts, it may be feasible to dissect out the implicated vein and surrounding tissues, or at any rate to remove the disintegrating clot after placing a ligature upon the vessel between the thrombus and the heart. A typical illustration of such treatment is that adopted for infective phlebitis of the lateral sinus complicating disease of the middle ear, where, after tying the internal jugular in the neck, the sinus is exposed, opened, and all the infected clot removed, partly from above, partly from below; admirable results have been thereby

obtained. Where, however, such ideal treatment is impracticable, all that the surgeon can undertake is to render the primary focus as healthy as possible by free relief of tension and close care in asepsis. The abscesses must be dealt with, when possible, by early opening and drainage, or by aspiration; such wounds often heal well, and joints which have been distended with pus may recover with free mobility. Occasionally, however, although rigid asepsis has been maintained, the suppuration continues, and even sloughing of the abscess-wall may follow. If the general condition can be improved, a barrier of granulation tissue will form in time, and repair be established.

The **general** treatment is similar to that for septicæmia (p. 97).

CHAPTER V.

ULCERATION.

REVISED BY W. E. CARNEGIE DICKSON, M.D., B.Sc., F.R.C P E.

An **Ulcer** is an open wound or sore, due to the destruction of the surface tissues, which tends to persist, probably as a result of pyogenic infection, but may under favourable circumstances heal. Any part of the surface of the body may be attacked, but especially the lower extremities, whilst any mucous membrane may be similarly affected. Ulcers may be of any size, single or multiple, and in the latter case not infrequently are caused by infection one from another.

It is almost impossible to classify ulcers, so multifarious are they in type and so wedded are we to an old-standing, inexact terminology. It must suffice to suggest that three chief **classes** are met with in surgical practice—viz.:

(1) Ulcers due to traumatism, including burns, or to non-specific pyogenic bacteria, *e.g.* the spreading, healing, chronic, etc.

(2) Ulcers due to specific bacteria, *e.g.* soft chancre, typhoid, tuberculous, syphilitic, etc.

(3) Malignant ulcers, *e.g.* rodent, epitheliomatous, scirrhous, and fungating.

We propose in this chapter, however, to deal merely with those ulcers which can be included under the first heading; the remainder are described elsewhere.

Ulcers due to Traumatism or to Non-Specific Pyogenic Bacteria.

Any form of surface irritant, whether chemical, thermal, radio-active, mechanical, or infective, may cause ulceration, and all the factors predisposing to inflammation will hasten its occurrence. Faulty nutrition, whether from defective local vascular supply or from long-standing congestion, is particularly liable to further the ulcerative process; thus, in the lower extremity it is predisposed to, on the one hand, by arterial disease which leads to a diminished blood-supply, or, on the other, by the passive congestion due to varicose veins. General debility, such as results from various forms of anæmia, Bright's disease, diabetes, etc., will also favour the occurrence of ulceration. Moreover, when any part becomes anæsthetic, or is cut off from its trophic centres, the continued

presence of an irritant may not be appreciated, and hence destructive inflammation occurs, *e.g.* corneal ulcer following section of the fifth nerve: or perforating ulcer of the foot in tabes: hot bottles applied to the feet or elsewhere in old people or in persons suffering from nervous lesions, etc. In malignant disease the projection of the mass of the growth may expose it unduly to irritation; but the chief cause of ulceration is the replacement of the deeper layers of the skin or mucous membrane by the cells of the neoplasm, so that, partly from interference with their blood-supply, and partly by their infiltration and destruction by the tumour, when the superficial epithelium wears off or is lost, it cannot be reproduced.

Clinical History.—Apart from the case of malignant ulceration, or in some 'trophic' and other forms of ulceration, ulcers of this class tend sooner or later to recovery, and so may be said to pass through three stages, viz., (1) that of ulceration proper, or extension; (2) a stage of transition, or preparation for healing, which may be of variable duration, according to whether the ulcer is running a rapid or a slow course, and persists until the surface is covered with granulations; and (3) the stage of healing or repair. The first stage alone represents the true ulcerative process. Naturally, in a large ulcer the three stages may co-exist, or a healing ulcer may from intrinsic or extrinsic causes relapse again to the stage of tissue destruction.

Stage I. : Ulceration Proper, or Extension.—The special characteristic of this stage is that destructive changes are progressing with greater or less rapidity, and hence the ulcers may be described as inflamed, spreading, or sloughing.

Naked-eye Appearances.—Surface, covered with ashy gray or dirty yellow material, partly slough, partly lymph, partly breaking-down tissue; no granulations are present; discharge, considerable in amount, thin, sanious, and often irritating and offensive, rarely purulent; margins, thickened and inflamed, and the surrounding tissues often œdematous and infiltrated; edge, sharply cut and well defined; the base of the ulcer is thickened and fixed to the underlying structures. In fact, the phenomena are those of an acute spreading superficial inflammation, which terminates in tissue-destruction.

Treatment resolves itself into removing the cause, and protecting the surface from mechanical or other irritation. The inflamed part must be kept at rest, and if necessary raised from a dependent position (*e.g.*, the leg must not be allowed to hang down), whilst the sore is dressed with moist and warm mild antiseptic applications, such as a boracic or starch-boracic fomentation. When the parts are very offensive, a charcoal and linseed-meal poultice may be first employed.

Stage II. : The Transition Period comprises all the changes which occur from the termination of the ulcerative process proper to the time when the process of healing is fully established by the wound becoming covered with granulations. In short, it may be described as the stage of preparation for healing.

Naked-eye Appearances.—When the destructive process has ceased, the surface of the ulcer begins to clean, and becomes, as it were, glazed over; sloughs are removed in the dressing or absorbed. The discharge becomes less abundant and more serous in character, and the angry red blush is replaced by a rosy hyperæmia. The infiltration of the base diminishes, so that the tissues around are less fixed and more supple. The film on the surface becomes more defined, and in the course of time, shorter or longer according to circumstances, little red vascular spots appear, which gradually increase in number and size, and coalesce, until the whole surface is covered by what has now become granulation tissue. The processes occurring in this stage are: (*a*) the removal of sloughs; (*b*) the covering of the surface with a cellulo-plastic exudate; and (*c*) the vascularisation thereof, and its conversion into granulation tissue. These do not necessarily go on equally all over the surface at the same time, and thus much variety in its appearance may be manifested; whilst at times the reparative changes may come entirely to a standstill. Hence all forms of chronic ulcer which are neither spreading nor actively healing may be included in this transitional stage, *viz.*, the indolent or callous ulcer, the irritable, the varicose, etc.

Indolent or Callous Ulcers occur most frequently on the legs of women about the middle period of life. Their chronic character may often be due largely to neglect on the part of the patient. Gradually the sore increases in size and depth until it may even involve the whole circumference of the limb. The surface is usually smooth and glistening, and of a dirty yellow colour, with perhaps a few badly-formed granulations; the edges are hard and sharply cut, and elevated considerably above the surface, whilst the skin around may be heaped up over the edge, and either covered with sodden cuticle or congested. The skin around is often deeply pigmented from chronic congestion, the pigmentation starting in the separate papillæ as maculæ, which gradually coalesce. The discharge is purulent or serous, and may be so abundant and irritating as to cause eczema of the parts around, and thus give rise to one form of eczematous ulcer. The base consists of scar-tissue, more or less abundant according to the age of the lesion and often extremely dense; it is adherent to the underlying tissues, fasciæ, etc.; and this constitutes one of the main difficulties in healing, as contraction is thereby prevented. If the ulcer is situated over a bone, such as the tibia, chronic periostitis results, and a subperiosteal node is formed, corresponding to the size and situation of the ulcer, forming a mushroom-shaped projection, and possibly going on to necrosis or to diffuse osteo-periostitis of the bone. These ulcers are sometimes very painful from pressure on cutaneous nerves, and thrombosis not infrequently occurs in both veins and lymphatics of the limb, leading to chronic œdema of the foot, often of a very solid, brawny type, and even to pseud-elephantiasis.

A somewhat similar condition may also follow large burns or extensive wounds on any part of the body; healing proceeds to a

certain extent, and then the contraction of the cicatricial tissue already formed interferes with the vitality of the part still unhealed by compressing the vessels which supply the granulations.

The so-called **Irritable Ulcer** is usually met with in this stage. Its chief peculiarities are the position, generally in the neighbourhood of the ankle, and the pain which accompanies it. The surface of a healing or chronic ulcer can usually be touched without the patient complaining; but in this variety the pain is excessive, especially at night. It was pointed out by the late Mr. Hilton that, if a probe is run lightly over the surface of such a sore, one or more spots will be indicated as the chief seats of the pain, the rest being insensitive. In all probability, nerve-filaments are there exposed, as the pain has a very marked burning or shooting character.

The **Varicose Ulcer** occurs in the leg of a patient who is the subject of varicose veins, especially when the smaller venules are involved. The skin becomes passively congested, and its nutrition impaired; any injury or abrasion, which would readily heal in a sound limb, is likely under such circumstances to give rise to a chronic sore. Again, it may be preceded by eczema resulting from the irritation of dirt or the friction of hard trousers, whilst occasionally it is due to the yielding of the thinned skin which forms the only covering of a much dilated vein, an accident often leading to severe hæmorrhage. The characters of a varicose ulcer in the main correspond to those of the indolent variety; it is usually situated on the inner and lower portion of the leg, whilst syphilitic sores are more often placed nearer the knee and on the outer side.

Treatment.—In this stage the treatment differs according to the conditions present. If it is merely a passing phase in the progress of an ulcer tending rapidly to repair, the same course of treatment should be adopted as in the earlier period, *viz.*, rest and protection from irritation. It may be advisable to shield the surface from contact with dressings by the intervention of a small portion of purified 'protective'—*e.g.*, oiled silk coated with dextrin—so that the reparative material may not be damaged during their removal.

The Chronic Ulcer needs much care in its treatment, and some cases require operative interference. Rest in a more or less elevated position is absolutely essential in order to relieve the congested condition of the limb; if the ulcer is situated over a joint, that structure must, of course, be immobilised. If the surface is foul, a charcoal poultice may be beneficial, or the sore may be dusted over with iodoform, and boracic fomentations applied. This may be preceded in some cases by touching the surface with solid nitrate of silver, or with a solution of chloride of zinc (40 grains to 1 ounce).

Pressure has been found of considerable service in the treatment of these ulcers; an ordinary bandage, reaching from the toes to the knee, will suffice in some cases, a suitable dressing of boric acid ointment, with perhaps some resin ointment added to make it more stimulating, being first applied. Martin's indiarubber bandage is useful when the veins are much enlarged.

The method of dealing with chronic ulcers suggested by Professor Unna, of Hamburg, has given excellent results. It consists in the use of an adhesive plaster, made up as follows: Gelatin, 5 parts; oxide of zinc, 5 parts; boric acid, 1 part; glycerine, 8 parts; water, 6 parts; to this ichthyol (5 per cent.) may be added with advantage. The limb is first washed thoroughly with soap and water and shaved, and then purified with carbolic or sublimate lotion. It is then wrapped round with a single layer of sterile gauze, and the paste, liquefied by placing it in a gallipot in a saucepan of boiling water, is applied over it with a paint or paste brush. Another layer of gauze is placed over the paste and a thin bandage over all, and the whole allowed to dry. Where there is extensive varix, the paste should extend from the ankle to the knee, and may sometimes include the foot. If there is much discharge, the ulcer should not be covered, and the dressing should be reapplied daily; but after it has diminished in amount, the paste may be carried right over the sore, and left in position for a week, or even longer.

When the edges are very indurated and thickened, and all action is at a standstill, Syme's suggestion may be followed, viz., to blister the whole surface, as well as the surrounding skin. A more satisfactory method, but requiring an anæsthetic, is to scrape the surface with a sharp spoon, and then to rub in a strong solution of chloride of zinc. Zinc ionization will also be effective. When healthy action has been obtained, assistance in healing may be secured by the use of such stimulating applications as scarlet-red (a coal-tar derivative) used for twenty-four hours in the form of a 4 to 8 per cent. ointment, after effective purification, followed for two days by boric acid ointment, and then repeated; or the liquid extract of the comfrey (*Symphytum officinale*), the active agent in which is akin to allantoin, will stimulate the growth of granulations; or allantoin itself may be employed in a 5 per cent. solution. Any of these agents will hasten a cure. If, however, the healing surface is very extensive, skin-grafting may be employed, but only if the patient can rest for a prolonged period. In bad cases where a considerable portion of the circumference of the limb is involved, when the ulcer is very callous and its base attached to the tibia, causing severe pain at night from chronic periostitis, and especially when the patient cannot obtain prolonged rest, *amputation* may be the best treatment. Farabœuf's amputation at the site of election can sometimes be undertaken with advantage.

Where varicose veins exist, treatment by injection should be carried out (see p. 389).

The Irritable Ulcer may be treated by dividing the exposed nerve just above the painful spot or by thorough scraping under an anæsthetic.

The Eczematous Ulcer requires soothing applications, such as lead lotion, and when once the acute stage has passed, tarry preparations (liq. carbonis detergens, 1 ounce to 1 pint of lotio plumbi), or an ichthyol ointment (5 to 10 per cent.), may be bene-

ficially employed. A mixture of benzoate of zinc and boric acid ointments is a very useful application, or Unna's paste with ichthyol may be utilised.

Stage III.: The Process of Repair being now fully under way, we have to deal, not with a healthy ulcer, for such a condition cannot exist, but with a healthy granulating wound, the result of ulceration, or, as we call it, to avoid confusion, a 'healing ulcer.'

A **Healing Ulcer** is characterised by the following conditions: Surface, smooth and even, shelving gradually from the skin, and covered with healthy granulations; these present a florid red appearance, are painless, and bleed, but not too readily, on being touched. The discharge is merely serous if the surface is kept at rest and free from all irritants; but should it become infected, or be dressed with irritating antiseptics, ordinary pus is formed. The surrounding skin is soft, flexible, and free from congestion, and the base is similarly free from fixity. The margins present a healing edge, which has been described as manifesting three coloured zones: within is a red area consisting of granulation tissue, covered by a single layer of epithelial cells, which cannot be seen except in a good light; next comes a thin dusky purple or blue line, where the granulations are covered by a few layers of epithelium, and the circulation is becoming retarded owing to cicatricial development; whilst outside is a white zone due to the heaping up of sodden cuticle upon the healthy or healed part.

The method of repair in such a wound consists in the transformation of the deeper layer of granulations into fibro-cicatricial tissue, which gradually contracts and finally becomes covered with epithelium. For full description see Chapter IX.

If emollient applications are used too long, the granulations become pale, protuberant, and œdematous, and the healing process is temporarily checked. A depressed general condition of the patient, or a varicose condition of the veins, may also account for this, and the term **'weak ulcer'** is applied to it. The prominent flabby granulations, popularly known as 'proud flesh,' appear to be due to the production of scar-tissue in the deeper part of the ulcer which compresses the vessels and leads to œdema of the overlying granulations. The process of repair can proceed only with difficulty under such circumstances, and it is usually necessary to remove them by caustics or mechanical means—*e.g.*, the curette.

Treatment.—The part must be kept at rest in a suitable position, and the surface protected by a dressing which does not stick. A piece of sterile protective, the exact size of the lesion, may be placed over it, and covered with sterile gauze, or the wound may be dressed with a simple ointment (*e.g.*, ung. acidi borici, diluted with an equal part of vaseline) spread on sterile butter-cloth or lint. Prominent granulations may be lightly touched with nitrate of silver, or a stimulating lotion applied, such as that known as lotio rubra (℞ Zinci sulphatis, gr. ii.; tinct. lavandulæ co., spir. rosmarini, āā ♏xx.; acidi borici, gr. x.; aquæ destill. ad ℥i.).

PLATE II

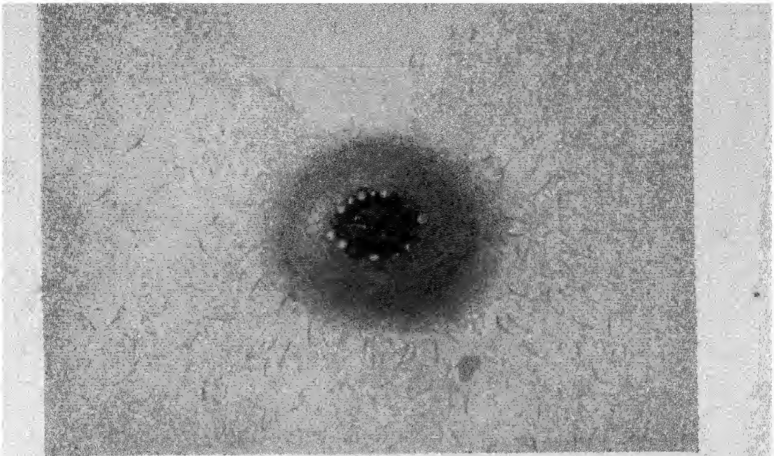


Fig 1.—Malignant Pustule.

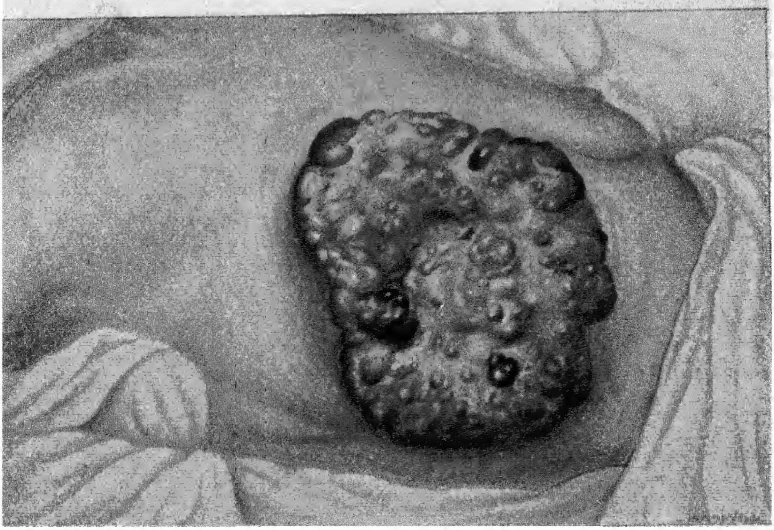


Fig 2.—Fungating Carcinoma of outer side of the right Breast (Fungus Hæmatodes)

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Skin-grafting, or the transplantation of more or less of the thickness of the skin from a healthy to a healing part, was introduced by Reverdin in 1869, and has since been much elaborated, and is employed for large surfaces. The following are the chief methods employed:

1. Transplantation of small pieces of the cuticle and cutis, Reverdin's original plan. A small portion of the cutaneous tissue is pinched up with or without forceps, and removed by a pair of sharp curved scissors. It should include the cuticle and a portion of the cutis vera, so that a drop or two of blood will slowly ooze from the denuded surface. The graft is gently placed cutis downwards on the surface of the granulations and covered with sterile protective. Many grafts may be applied at the same time, and the whole wound carefully dressed and protected. If there is much discharge, the grafts will not 'take'; but, if the surface is healthy, there should be no difficulty in getting them to grow. Usually they disappear for a day or two, from the cuticle becoming softened or disintegrated; but soon the epithelium spreads, and makes itself visible as a distinct centre of repair.

2. Transplantation of large portions of cuticle as suggested by Thiersch. This method consists in removing large strips of cuticle with a razor, and implanting them on a fresh wound or on a raw surface denuded of granulations by scraping; all hæmorrhage must be previously stayed by pressure. In cutting the strips of cuticle care must be taken to make them as thin as possible; the papillæ are always encroached on, however, and hence some amount of blood escapes, in which the grafts are allowed to remain soaking until required for use. The grafts are applied in such a way that they overlap each other and also the margins of the defect. There is always some tendency for the edges to turn in, and this must be prevented by gentle manipulation. They are then dressed with dry sterile gauze, though some surgeons still prefer to keep the grafts covered with protective, or with perforated tin or thin silver-foil. There is usually no need to look at the wound for some days. The outer sides of the thigh and arm are the best places from which to take grafts; the wounds caused by their removal are dressed by sterile gauze over protective or by gauze soaked in tannic acid, and usually heal quickly, if the razor has not encroached on the subcutaneous tissues. The scar which results from the healing of the grafts is generally soft and supple, and free from the tendency to excessive contraction which marks the ordinary cicatrix.

3. The whole thickness of the skin is used in some instances (Wolfe graft). The graft is cut rather larger than is necessary, to allow for shrinkage, and all subcutaneous tissue and fat removed therefrom. It is applied to the raw surface of the wound after scraping away all granulations, and stitched into position. It may also be applied directly to an operation wound, when the edges cannot be brought together.

4. Unfortunately, the complete detachment of the flap, associated as it is with a complete severance of the blood-supply, is sometimes followed by its loss of vitality, and to avoid this accident pedunculated flaps (Pedicle-grafting) are now often employed not only to cover raw surfaces, but also to build up parts that have been destroyed, as in plastic oro-facial surgery (*q.v.*). It is impossible here to discuss this procedure in detail, but as an illustration of its utility may be mentioned the covering of a raw surface after a burn over the front of the elbow-joint, where movement would be much restricted by the development of an ordinary scar. In such a case a pedicled flap should be raised from the lateral abdominal wall and stitched in position to the arm, which is suitably fixed by bandages to the side; when union has occurred, the pedicle is divided and the arm set free. It is, of course, possible to employ another person as the donor if arrangements can be made to secure immobility during the period of healing.

CHAPTER VI.

NECROSIS AND GANGRENE.

REVISED BY W. E. CARNEGIE DICKSON, M.D., B.Sc., F.R.C P.E.

CONSIDERABLE difficulty has been encountered in the past owing to the common use of these two terms as practically synonymous, whereas, from the pathological standpoint, **Necrosis** may be defined as ' the death and degeneration of single cells or of larger or smaller groups of cells, together with corresponding changes in the intercellular elements, in the living body.'* **Gangrene,** on the other hand, is ' that condition of any of the tissues of the body in which there is **necrosis combined with putrefactive changes.'**† Thus, to speak of ' aseptic gangrene ' is to make use of a contradiction of terms, though in some of the forms of ' dry ' gangrene the putrefactive processes may be of subsidiary importance from the clinical point of view, although organisms of putrefaction *are* actually present in the gangrenous tissues.

Necrosis, from the surgical and clinical point of view, may for convenience be regarded as a term applied to the death of an appreciable area of tissue, whether occurring within the substance or on the surface of an organ or tissue, though the series of processes occurring subsequently will naturally vary according to the causes at work, which may be multiple in any given case, the position and extent of the lesion, and the nature and vitality of the tissue or tissues involved, and also the age and resisting powers of the patient.

For the detailed descriptions of the histological changes occurring in individual dying or dead tissues within the living body, the reader is referred to textbooks of pathology, and we shall here attempt to deal only with the more immediate and practical points in connection with causation, symptomatology, and treatment. In any given case, the terms ' septic ' and ' aseptic ' are often purely relative, and similarly it is frequently difficult to differentiate between necrosis and gangrene, all degrees of these in combination being possible. With this preliminary explanation, the reader will therefore pardon what may, in the following descriptions, from the purely scientific and pathological point of view, appear to be a somewhat loose employment of the terms ' septic ' and ' aseptic,' ' necrosis ' and ' gangrene.'

Causes of Necrosis.—Of these the most important are:

* Beattie and Carnegie Dickson's ' Textbook of Pathology,' 3rd edition, 1925, p. 94.

† *Ibid.*, p. 105.

(1) **Interference with the blood-supply** from narrowing of the arteries by disease: blocking of the lumen by thrombosis or embolism, or by ligature, compression from without by tumours, etc.: rupture or tearing of the vessel-wall. If there is a free collateral supply, the results are usually less serious than where anastomosis is scanty, **infarction** occurring where arteries which are more or less 'terminal' are blocked, *e.g.* in the heart-wall, lung, spleen, kidney, mesentery, etc. The supply of arterial blood may also be diminished by spasmodic contraction of the vessels, especially the arterioles, *e.g.* in Raynaud's disease or in ergot-poisoning. If, in addition, the heart's action be enfeebled or the blood itself of poor quality, the effect of the foregoing will be aggravated.

(2) **The action of bacteria and their toxins,** *e.g.* in the production of superficial necrosis of the mucous membrane in diphtheria, Vincent's fusi-spirochætal infection, etc.: or of caseous necrosis in tuberculosis: or of the central necrotic mass in boils and carbuncles by staphylococci, etc.

(3) **The action of physical and chemical agencies,** such as continuous pressure, crushing injuries or laceration, heat or cold, X-rays, ultra-violet, radium and other forms of radiation, corrosive acids, caustic alkalies, tissue-coagulants and poisons such as corrosive sublimate, carbolic acid (p. 132), etc.: enzymes, such as those of the pancreas (trypsin and lipase) when they obtain access to the tissue, such as the fat of the mesentery or omentum in cases of pancreatitis.

(4) **Diseases of nerves or nerve-cells** interfering with their neuro-trophic influence upon the tissues of the part, as in various lesions of the spinal cord, neuritis, etc.

The series of changes occurring in the necrotic area, and the ultimate result will depend especially on the locality and extent of the area involved. If in the substance of an organ, and if small and not infected with organisms, absorption, or partial absorption and encapsulation, and perhaps calcification may occur, as in many non-infected infarcts. Central softening and the formation of a pseudo-cyst may supervene, *e.g.* in the brain. Suppuration and abscess-formation may ensue, for example, in septic infarcts; or, if organisms of putrefaction gain access or are already present, gangrene may supervene, *e.g.* in necrotic lesions of the intestine, lung, or if they include surface tissues of the body, *e.g.* in a limb or elsewhere.

When these processes occur in soft surface tissues, the condition is often termed sloughing, and the dead mass a slough, which may or may not be gangrenous. If a tangible portion of bone dies, the necrosed mass is called a sequestrum.

Gangrene may affect simultaneously the hard and soft tissues of a limb, the genitals, some localised area, say, of the face or elsewhere, a strangulated or infarcted loop of bowel, a portion of diseased lung, or it may occur in wounds, either as a secondary or as a primary process.

For purposes of description, we may consider first the condition as it may attack part of a limb, say, the foot.

General History of a Case of Gangrene.

Signs of Death.—Death of a limited portion of the body can be recognised prior to the supervention of evident subsequent changes in the dead tissues, by five characteristic signs:

1. Loss of pulsation in the vessels.
2. Loss of heat, since no warm blood is brought to it.
3. Loss of sensation in the dead part, although much pain of a referred type may be experienced whilst its death is occurring.
4. Loss of function of the gangrenous mass, which, if it is a limb, lies flaccid and motionless.
5. Change of colour, the character of which depends on the amount of blood present at the time of death; if the part is full of blood, it becomes purple and mottled; if anæmic, a waxy or cream colour results.

Before the actual death of the part, these five signs may be in measure present when the vitality of a limb is seriously depressed, as by ligature of the main vessel or by its embolic obstruction; but, if they continue for any length of time, death of the tissues is certain to ensue. Sometimes it is difficult to determine whether such a part is actually dead, especially when it is engorged with venous blood and the arterial pulsation has ceased. If living, it will usually be found that pressure causes some modification of the colour, and that the discoloration returns when the pressure is removed.

Changes occurring in the Dead Tissues.—The character of these depends mainly on the condition of affairs at the time of their death, and whether or not active putrefaction supervenes.

1. **Dry Gangrene.**—In this form there is **death** and **drying up** or **mummification,** which can occur only when the tissue involved is, previous to its death, more or less drained of its fluids, and where there is free evaporation. The usual cause is chronic arterial obstruction, as brought about by arterio-sclerosis or calcification of the terminal arteries, to which a sudden or gradual complete occlusion of the main trunk is often superadded. The dead part becomes hard, dry, and wrinkled, and is of a dark brown, greenish-brown, or almost black colour from the diffusion of the disintegrated hæmoglobin. The more fleshy parts (*e.g.*, above the ankle) rarely undergo perfect mummification, and are often considerably inflamed, and sometimes horribly offensive.

2. **Moist Gangrene** (Plate III.) arises when a part of the body full of fluid dies, and is associated especially with conditions which involve venous obstruction as well as a sudden arterial block—*e.g.* in traumatic gangrene due to pressure upon, or rupture of, the main artery. Obviously, such a condition is well suited for the development of the organisms, which always exist in numbers on the skin.

Where necrosis has occurred in moist tissues, but where the organismal infection is minimal and can still be kept under control, the dead tissues become more or less discoloured, either purple or

any shade from black to yellow, green or white. The part remains of much the same size and consistency as at the time of death so long as it is kept from further contamination, and is then simply and quietly cast off from the surrounding tissues without any obvious inflammatory disturbance.

When the putrefactive processes are active, the resulting **Putrid Moist Gangrene** is associated with a rapid breaking-up and disintegration of the mass, which becomes black, green, or yellow. The cuticle is raised from the cutis vera by blebs containing stinking serum, or even bubbles of gas, and these can be readily pressed along under the epidermis for some distance. The tissues of the limb are soft and lacerable, and on grasping them emphysematous crackling is usually noted.

The **Later History** of a necrotic or of a gangrenous mass depends upon the nature and amount of the organismal infection, and also on the bulk of the affected area.

(*a*) If the necrotic area is small in size and either not, or only mildly, infected, it may, under favourable circumstances, be **entirely absorbed** in the same way as is a catgut ligature. This is often observed after sloughing of small portions of amputation flaps; if the part is kept dry and as aseptic as possible, it is gradually removed, and when the process is completed a small dark scab will fall or be picked off, and a cicatrix be found beneath it. In a similar way dead bone may be absorbed, if the sequestrum is not too large or too dense, and if it is in close proximity to healthy vascular tissue. The dead portion is first invaded by phagocytic cells, some of them leucocytes, others derived from the connective-tissue and endothelial cells of the part, which infiltrate and gradually remove it; granulation tissue replaces it, and this in turn is converted into a cicatrix, and covered with cuticle in the usual way (see Repair, Chapter IX.).

(*b*) If the mass, though aseptic, is of such a size, or consists of tissues of such a character, as to prevent its total absorption, or if the vital activity of the patient is lowered, a modification of the same process results in **partial absorption** of the dead material, whilst the remainder is separated by a simple process of anæmic ulceration, and, if on a surface, is cast off as a **slough.** The dead part immediately contiguous to the living is removed and replaced by granulation tissue, and this change continues advancing into the mass until the layer of granulations which has penetrated furthest is at such a distance from its nutritive base as to be unable to derive from it sufficient pabulum, owing to the contraction of the cicatricial tissue which is forming behind; and then a simple ulcerative process from defective nutrition causes a **line of cleavage** to form between the living and dead, and by this means the latter is separated from the body. The size of the portion thus cast off is distinctly less than that of the original necrotic mass. This process is associated with local reparative, rather than with active inflammatory, reaction, and but little resulting constitutional disturbance; it is slow in progress, but there are none of the risks attaching to the more rapid

septic process. Of course, the denser and harder the tissues, the longer they take in separating, and hence, when a whole limb is involved, it is possible for the soft parts to have separated, and the wound caused thereby to have cicatrized before much impression has been made on the bones. Considerable retraction ensues, giving rise to a 'conical stump,' from the apex of which the bone protrudes.

(*c*) If the necrotic portion is septic, and especially if it be definitely gangrenous, its **separation** is accomplished by inflammatory processes taking place in, and at the expense of, the surrounding living tissues. The extent of the gangrene is primarily indicated by a **line of demarcation,** due to the change in colour occurring in the dead part, the living tissues retaining their normal hue. Apart from any actual septic process also at work, the irritation of the chemical products formed in the dead mass causes inflammatory reaction in the surrounding structures, which ends in suppuration, whilst a layer of granulation tissue forms at the limit of the living portion, and thus the **final line of separation** is produced. Clinically, one notices in this latter stage a bright red line of hyperæmia at the extremity of the living tissues, which gradually spreads and deepens until about the eighth or tenth day, when, if the cuticle is intact, the living and dead parts are separated by a narrow white or yellow line, which is proved, on pricking the epidermis, to be due to the presence of a layer of pus; as the pus escapes, a shallow groove is seen running between a granulating surface on the side of the living tissues and the grangrenous mass. This process, gradually extending through the whole thickness of the limb, is accompanied by the local signs of inflammation, and by fever, the degree of the latter depending on the amount of toxic material absorbed. The inflammation, moreover, is not always limited to the line of separation, but may spread upwards along the lymphatics or veins, or in the fascial and muscular planes, until, perhaps, the whole limb is involved in an extensive suppurative process.

The **Constitutional Symptoms** in cases of gangrene may be described under two distinct headings:

(*a*) Those general conditions which predispose to the occurrence of gangrene, and which are mainly of a debilitating character, such as diabetes and albuminuria, and other conditions affecting either the composition of the blood or the vitality of the limbs.

(*b*) Those conditions resulting from the presence of the dead tissue and its connection with the body. Various forms of toxæmia result, usually causing fever, asthenic in type and variable in degree. Pain, moreover, is frequently a prominent feature in some forms of gangrene, and the patient is liable to become exhausted from this cause.

But little need be said as to the **General Treatment** of gangrene, beyond that the strength of the patient must be maintained by plenty of easily assimilable food, sufficient stimulant, and tonics. Pain and sleeplessness must be combated by the administration of a suitable amount of opium or morphia, if the kidneys are healthy.

Diabetes and albuminuria require appropriate dietetic and therapeutic measures.

Local Treatment.—In the early stages when gangrene is threatening and not yet definitely established, the surgeon's aim is directed towards **prevention,** and for this chief reliance is placed on improving the circulation and keeping the part warm. The limb is slightly raised so as to assist the venous return and thereby prevent stasis, thus helping to improve the arterial supply. When it seems likely that an element of spasm is present, the operation of **periarterial sympathectomy** introduced of recent years may be employed. The sympathetic supply to the arterial trunks enters the sheath of the vessel high up and travels down to the smaller divisions as a plexus in close proximity to the outer wall. If a complete circular removal of this plexus is undertaken in the upper part of the limb—*e.g.*, around the common femoral artery—the spasmodic contraction of the vessel below this level ceases, with the result that the blood-supply improves, the temperature of the part rises, and the vitality is increased. The value of this method of treatment has been definitely established in several types of threatening gangrene, and further reference will be made to it below. A similar result, it is claimed, can be secured by injecting the periarterial sheath with absolute alcohol, which destroys the plexus. Apart from these methods, hot-air baths may be serviceable, but if these cannot be provided, the limb is wrapped in warm, dry cotton-wool carefully sterilised, and moderate elastic pressure is maintained. Under all circumstances the greatest care is taken to ensure as complete asepsis of the part as possible. If measures such as these fail and gangrene supervenes, **amputation** will be required sooner or later, and the rules that govern the time and level of this procedure will be given in the appropriate sections.

Varieties of Gangrene.

We have already enumerated the chief causes of **Necrosis** or death of an area of tissue or tissues within the living body (p. 112); and of necessity these are practically identical with the causes of gangrene, in which putrefaction is superadded. For convenience of description, the following classification of gangrene is one which, though admittedly imperfect and necessitating a certain amount of repetition, does in a measure group together allied types of the affection, and will serve as a useful one for practical purposes:

I. **Secondary** or **Symptomatic Gangrene,** or that predisposed to by preceding vascular or general conditions, and where a trauma, if present at all, is of very slight significance.

- (*a*) Gangrene from embolus.
- (*b*) Senile gangrene.
- (*c*) Gangrene from arterial thrombosis (when non-senile).
- (*d*) Diabetic gangrene.
- (*e*) Raynaud's disease.
- (*f*) Gangrene due to ergot.

II. **Traumatic Gangrene,** which may be due to direct or indirect injury, and where the damage done to the vesssels or tissues by the trauma is the immediate cause of the loss of vitality. Two varieties may be described, *viz.*:

(*a*) The indirect, where the lesion involves the vessels of the limb at some distance above the locality where the gangrene occurs.

(*b*) The direct, where the gangrenous process is limited to the part injured.

III. **Primary** and **Secondary Infective Gangrene,** which arises more especially and specifically from the activity and influence of micro-organisms.

(*a*) Acute inflammatory or spreading traumatic gangrene.
(*b*) Wound phagedena and hospital-gangrene.
(*c*) Noma and cancrum oris.

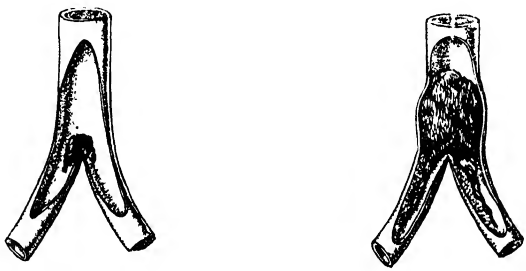
IV. **Gangrene from Physical or Chemical Causes**—frost-bite, burns, etc.

I. Symptomatic Gangrene.

(*a*) **Embolic Gangrene.** (For general details as to embolism, see Chapter XIV.) When the main artery of a limb becomes blocked by a simple, *i.e.* non-infected, embolus, the condition is exactly similar to that which obtains after ligature, and under ordinary circumstances should not lead to gangrene; but, if either the general or local vitality is much reduced, the occlusion of the main trunk may be sufficient to determine the death and consequent gangrene of more or less of the limb. Thus it may occur: (i.) Where the embolus consists of a fibrinous vegetation detached from one of the cardiac valves in a case of endocarditis following rheumatic or other fevers. The general nutrition has been depressed by the preceding fever, the heart's action is weak, and the circulation possibly impeded by the valvular lesion, so that the occlusion of a main trunk, even in a young person, is often sufficient to determine gangrene. (ii.) Embolic gangrene may also follow the impaction of a detached atheromatous plate or vegetations from an atheromatous patch in an artery, *e.g.* the aorta or one of its branches, or a main vessel of a limb, the circulation in which has been previously impaired by arterial degeneration, an occurrence not unusual in elderly people.

Emboli are most commonly arrested at the sites of division of the main trunks (Fig. 26, A), or where the calibre is suddenly diminished by the origin of a large branch, the embolus sometimes saddling over the bifurcation, and thus, as it increases in size by the subsequent deposit thereon of blood-platelets and fibrin, effectually closing both branches (Fig. 26, B). In the lower limb it may thus occur at the division of the femoral or popliteal: in the upper, at the origin of the superior profunda, or where the brachial divides.

The chief early **symptom** is sudden severe pain experienced both at the point of impaction and also down the limb along the course of the vessel. Pulsation below the block ceases, the limb becomes cold, useless, and devoid of sensation. If the vessels are healthy, venous stagnation follows, the terminal portion of the limb becoming congested and œdematous, and finally passing into a condition of moist gangrene. If, however, the terminal arteries are calcified or atheromatous, so that the limb is in a state of chronic anæmia, dry gangrene is likely to follow. The process starts peripherally, and spreads gradually upwards until it reaches a level where there is sufficient circulation to maintain the life of the part. This usually obtains in the neighbourhood of a joint, since there is always a more free anastomosis here than in the interarticular portions of the limb; thus, in the leg, the gangrene is likely to be arrested either immediately above the ankle or below the knee.



A B

FIG. 26.—DIAGRAMS OF EMBOLUS SADDLING THE BIFURCATION OF AN ARTERY.

In A the embolus is seen, and the commencement of a thrombus on it, but not yet obstructing the vessel; in B both branches of the trunk are blocked by the increase in size of the clot.

Treatment.—In the first place the distal portion of the limb must be rendered as aseptic as possible, special care being directed to the intervals between the toes and to the semilunar folds of the nails. If the site of the embolus can be located, and the patient can stand it, the artery may be exposed and incised longitudinally, and the embolus removed (**embolectomy**) with subsequent suture of the vessel (p. 343). A sufficient number of successful cases of this operation has been recorded to prove its value. Failing this, expectant treatment is adopted (p. 115), and if gangrene occurs amputation must be resorted to, but not until a definite line of separation has formed. Of course, the precautions as to maintaining as aseptic a condition of the dead part as possible must be observed throughout the course of the case. Should the dead portion become seriously infected, the site of amputation may have to be at a considerably higher level.

(*b*) **Senile Gangrene** occurs in elderly people, and is the result of imperfect nutrition of the tissues (Fig. 27). The toes are most frequently affected, but it is also seen in the hands, and may attack the nose, ears, or even the tongue.

Causes.—These are to be found mainly in the condition of the circulatory organs. (*a*) **Arterio-sclerosis** in any of its forms (*e.g.*, **endarteritis deformans** or **obliterans**) attacking the smaller arteries of the limb or part is usually present, as also possibly atheroma of the larger trunks. The vessels become pipe-like and inelastic in consequence, and incapable of accommodating themselves to the requisite variations in the blood-supply. Hence a fixed minimal amount of blood enters the limb, which passes into a chronic stage of ischæmia and malnutrition, whilst the tunica intima is often as rough as, with or without injury, to predispose to the occurrence

FIG. 27.—SENILE GANGRENE.

of thrombosis. (*b*) A **weak heart** is generally present, leading to low pulse tension, and increased difficulty in propelling the blood through the rigid and narrowed vessels; and (*c*) the **condition of the blood** may be impoverished, *e.g.* by albuminuria or glycosuria. When such predisposing factors are present, anything that results in (*d*) **thrombosis** either in the main trunks or in the peripheral arterioles or capillaries is likely to determine the onset of gangrene. Thrombosis of the main vessels may be due to a blow or strain which often passes unnoticed, or more frequently arises from a gradual deposit of fibrin on the already roughened walls. If the obstruction originates in the smaller trunks or capillaries, it is generally brought about by inflammation following some slight injury, such as striking the ball of the great-toe against the table, or even cutting a corn. Exposure to cold may also act as an exciting agent. In either case the clotting extends for some distance, and the height to which the

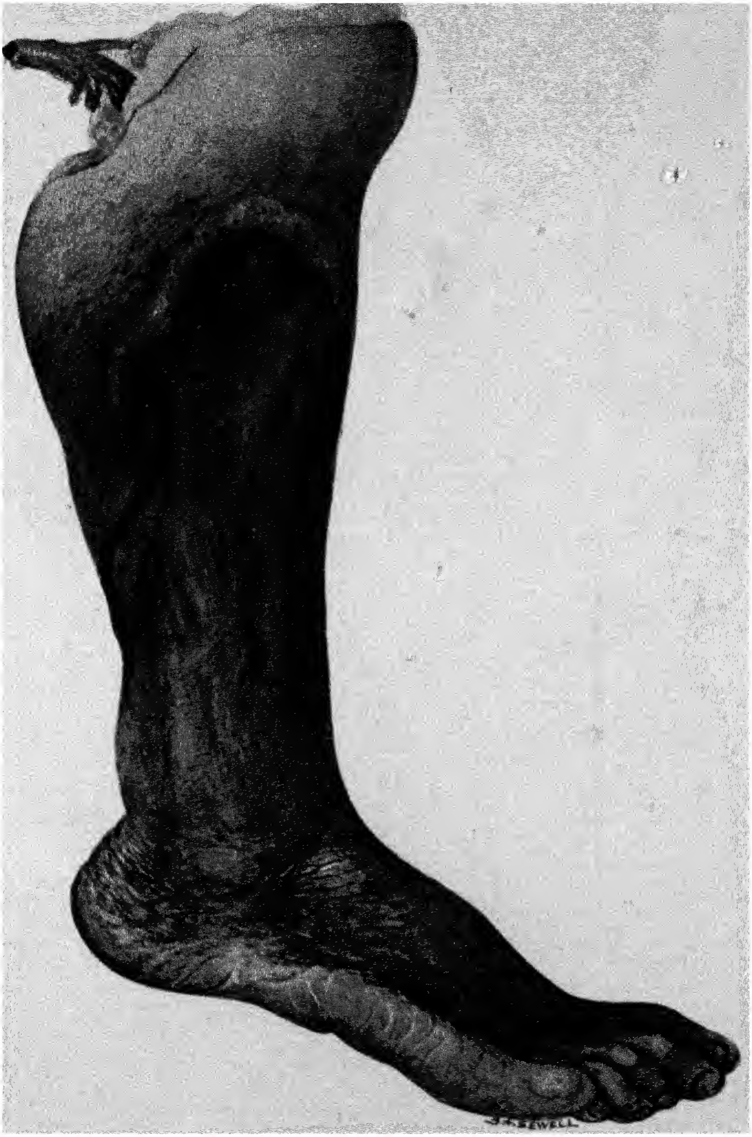
gangrene spreads will vary accordingly. The occurrence of such thrombosis is also rendered more liable by the presence of focal infection elsewhere in the body.

Symptoms.—Evidences of malnutrition of the limb have probably been present for some time in the form of cramp and pain in the muscles, which become fatigued rapidly, or of sensations of pins and needles or numbness. The pulsation in the tibials may be so slight as to be scarcely perceptible, and the whole limb is shrivelled and feels cold and heavy. The skin is often passively congested, and prone to ulceration or eczema. Finally, after some peripheral lesion, an area of painful redness is noticed, perhaps running on to ulceration, and in the centre of this patch a slough forms, which becomes dry and black; the process gradually spreads with more or less inflammation, so that it is sometimes known as **'inflammatory' senile gangrene.** If, however, it results from thrombosis of the main vessels, the local death occurs without the supervention of any appreciable degree of local inflammatory phenomena, the toes merely shrivelling up and dying (**'non-inflammatory' senile gangrene**). The inner side of the great toe is perhaps the commonest situation for this process to start, and thence it spreads from one toe to another, and also along the instep and up the ankle to the leg. Pain is always a marked feature, and, as the disease spreads, the patient becomes exhausted by its long continuance and by the consequent want of sleep. Septic fever, bedsores, or the intervention of some cardiac, pulmonary, or renal complication, may hasten a fatal termination.

Treatment.—In the earlier stages of malnutrition of a limb from defective arterial supply, much may be done to improve the vitality of the part by the cautious use of hot-air baths, massage, etc., and attention to the general health. The patient must be warned of the danger of small injuries, and the possible harm that may follow the injudicious use of hot-water bottles, or of incautiously cutting corns. If the condition progresses and actual gangrene is threatening, periarterial sympathectomy may be undertaken if it can be proved on X-ray examination that no serious calcareous degeneration of the arterial walls is present; even if it fails to prevent the onset of gangrene, it does no harm.

When gangrene is actually present, treatment is governed by the observation that, after any attempt to amputate through the neighbouring living parts, the gangrenous process is certain to commence again in the flaps; if merely cutting a corn suffices to originate the malady, much more will so severe an injury as an amputation. It is therefore necessary to amputate well away from the dead mass at a point where the blood-supply is sufficient to nourish the flaps, and yet not so near the trunk as to threaten life seriously through shock. This must be undertaken early, especially when pain is severe, or if a spreading cellulitis is present. In order to determine the most favourable site, the main artery should be carefully examined, and if feasible no operation is performed at a level where

PLATE III



Spreading Moist Gangrene from Thrombosis of Popliteal Artery.

[*To face page* 120

it appears to be occluded. It should also be remembered that the muscles are better supplied with blood than the overlying skin. The condition of the limb will therefore influence the surgeon's decision; if thin, attenuated, and shrivelled, it will be wise to amputate high. The operation should inflict as little damage as possible to the parts, the flaps being nearly equal in length and sufficiently thick to include plenty of muscle. Where the mischief is limited to the foot, it is usually advisable to amputate through the lower third of the thigh, or at any rate in the neighbourhood of the knee-joint, though not through the joint itself, as the flaps in that operation are always rather flimsy. If for any reason amputation is contra-indicated, the limb is kept as aseptic as possible, wrapped up warmly, and elevated. The general health is maintained by suitable nourishment, tonics, and stimulants, and pain alleviated by opium or morphia.

(*c*) **Gangrene from Arterial Thrombosis** (when **non-senile**) is not a common occurrence. It may arise as a result of the affection known as endarteritis obliterans, and may occasionally also develop in the later stages of typhoid fever and other toxic conditions in which the coagulability of the blood is increased. The femoral artery is most usually blocked, but occasionally the trouble will spread up to the aorta and involve both legs in the gangrenous process. Unless the veins are also involved, the gangrene is usually of the dry type. It is wise to wait until a line of demarcation has formed, and then amputate well above.

A similar condition is met with chiefly in Russian and Polish Jews who are heavy cigarette smokers, resulting from an affection which has been designated thrombo-angiitis obliterans (Leo Buerger), in which extensive thrombosis occurs first in the arteries and later in the veins of the leg. In the earlier stages, various sensory and trophic changes are noticed; and, in the later, gangrene, usually of the dry type, occurs. Periarterial sympathectomy has proved to be of the greatest value in this condition.

A limited gangrene of a dry type may occur in the tips of one or more fingers as a consequence of the pressure of a cervical rib on the subclavian vessels.

(*d*) **Diabetic Gangrene** is due mainly to the abnormal condition of the blood in diabetes, thereby reducing the power of the tissues to resist bacterial invasion; but it is also in measure the result of a sclerosing endarteritis and peripheral neuritis. It is also conceivable that the increased amount of sugar, etc., in the body-fluids and tissues provides a more suitable culture-medium for micro-organisms, *e.g.* streptococci, which grow much more luxuriantly in, say, nutrient broth when a small percentage of glucose has been added to the medium. It is not generally met with in the subjects of acute diabetes, nor in people under forty years of age. It results usually from some slight traumatic or infective injury, and often commences on the under side or at the extremity of one of the toes as a bleb, surrounded by a dusky purple areola. When the bleb is opened or

bursts, the central portion of the underlying tissue is found to be necrotic, and from this focus the gangrene spreads. If the part is kept as aseptic as possible, and in limbs with some degree of endarteritis, the dead part may shrivel and dry up (Fig. 28), especially with suitable treatment; but if such local and general precautions are not observed, extensive suppurative infiltration of the soft parts may follow, even though the necrotic process itself be of slight extent, and from this the patient may succumb, the fatal issue being due to septicæmia or toxæmia accompanied by diabetic coma. Not uncommonly several foci of mischief or a spreading erysipelatoid condition may develop, and the extent of subcutaneous involvement is sometimes much greater than the limited affection of the skin.

Fig. 28.—Diabetic Gangrene of Foot

Treatment.—In the less severe cases, involving one or more toes, it will often suffice to keep the part warm and as aseptic as possible, until it is separated by natural processes, or at any rate the surgeon merely completes the work by dividing or dissecting out bones. Naturally, the diabetic condition itself, and especially the acidosis, must be treated, if possible, by dieting, and in suitable cases the administration of insulin and other appropriate measures. Where there is more extensive involvement, the character of the treatment turns largely on the amount of vascular disease and the degree of the accompanying inflammation. If the vessels are tolerably healthy, amputation not very much above the upper limit of the gangrene is justifiable; but, if the main trunks are probably affected, a high amputation will be required, if the patient's general condition permits. When extensive suppuration is present, it is sometimes wise to lay the parts open and drain away the inflammatory exudate before undertaking radical treatment. Spinal analgesia should be employed when the lower extremity is involved, rather than any general anæsthetic.

Thus far, one has taken for granted that the surgeon is dealing with gangrene as it occurs in a genuinely diabetic subject. It remains to be stated that a toxic form of glycosuria can occur with-

out diabetes, and that it is not an infrequent symptom associated with diverse phenomena of the cellulitic type—*e.g.*, carbuncle, as also with dry gangrene. In these the copper-reducing content of the urine may be glucose or some other substance, such as glycuronic acid, and it is a product of the toxic absorption from the local focus. There is no accompanying polyuria or general disturbance, and the glycosuria disappears after the inflammatory or gangrenous trouble has been removed.

(*e*) **Raynaud's Disease** is a condition usually met with in anæmic or neurotic young women between the ages of fifteen and thirty. It is due to vaso-motor spasm, possibly the outcome of some

FIG. 29.—RAYNAUD'S DISEASE OF HANDS.

intestinal or other toxæmia. Three stages are described: (i.) local syncope or ischæmia, due to arterial spasm, and characterized by pallor and painfulness of the part; (ii.) local asphyxia, the affected tissues being blue and cyanosed from venous congestion; and (iii.) necrosis, the part becoming dry and black. The onset is often sudden, and the disease may last for a variable time, from days to months. If gangrene supervenes, the latter is the limit more often reached; but it by no means necessarily follows that tissue-necrosis occurs in every case. The disease is generally bilateral, and affects the fingers (Fig. 29) more frequently than the toes, and occasionally the tips of the ears or nose, but superficial patches may occur on any part of the body; the process is non-febrile and often very painful. Paroxysmal hæmoglobinuria has been observed, and is supposed to be due to vaso-motor disturbance of the kidneys. Ankylosis of the smaller interphalangeal joints and localized patches of anæsthesia, associated with neuralgic pain, are sometimes present, resulting from peripheral neuritis. The condition often resembles the later stages of a chilblain, but is distinguished by its more dusky colour, the greater pain, the absence of itching, and the fact that the process is not limited to exposed or terminal parts, or to cold weather.

Treatment in the early stages consists in attention to the general health, getting rid of sources of worry, avoiding the cold of winter by going to a warm clime, or by the use of suitable gloves or socks; the intestine is cleansed by mild purgation and the administration of abundant draughts of warm saline solution; menstrual irregularities and any focal septic lesions if present, *e.g.* in the tonsils, gums, tooth-sockets, etc., are suitably treated. Local preventive treatment consists in the use of stimulating embrocations or warm douches, but the best results follow the use of electricity. The constant current is employed, and preferably in the form of the electric bath, local or general as required, and repeated either once or several times a day. Periarterial sympathectomy may also prove of value. When actual gangrene is present, the dead tissue should be kept aseptic, when sooner or later it will be absorbed or separated.

(*f*) **Gangrene from Ergot** is a rare phenomenon in this country, but it has been known to occur when diseased rye has been used in the manufacture of bread. The resulting gangrene may vary in extent, and may lead to the loss of one or more fingers or toes or of the greater portion of a limb.

II. Traumatic Gangrene.

By traumatic gangrene is meant that variety occurring as the consequence of an injury, whether applied to the main bloodvessels (indirect traumatic gangrene), or directly to the tissues themselves (direct traumatic gangrene).

(*a*) **Indirect Traumatic Gangrene** arises from a considerable variety of lesions, and the course and clinical history are consequently also very variable.

(i.) **Ligature of the main artery** does not produce gangrene in a healthy limb; but should the latter be in a state of chronic malnutrition and deficient blood-supply from preceding arterial disease, death of a certain portion may ensue, the case running a course similar to one of gangrene due to embolus. It is usually of the dry type, and limited to one or two toes, or to a patch of the superficial tissues; but, if it reaches the more fleshy portions, the moist variety supervenes.

Treatment.—In cases where it is feared that the nourishment and vitality of the distal parts may be jeopardized, an attempt should be made to reduce the circulation gradually before completing the occlusion of the vessel; time is thus given for the opening up of a sufficient collateral circulation. This is best accomplished by dividing the artery after controlling the circulation through it and tying in a narrow silver cannula thoroughly coated with paraffin for four or five days, after which interval the cannula is removed and the vessel tied.

If gangrene has actually occurred, the parts must be kept warm and as aseptic as possible until a definite line of separation forms,

and then the natural processes at this level are assisted by dividing tendons and bones. If, however, a considerable area of the limb loses its vitality, and especially if the dead tissue is moist and putrid, an early high amputation is required.

(ii.) **Arterial thrombosis from injury** causes gangrene only under special circumstances, the course and treatment being similar to that resulting from an embolus.

(iii.) **Obstruction to both main artery and vein,** if it occurs suddenly, has been looked on hitherto as an almost certain precursor of gangrene. It has also long been recognised that, in conditions where the pressure has gradually increased up to the point of complete obliteration, it was possible to remove or tie both artery and vein without serious risk, as in excising cancerous glands or extirpating an aneurism; the collateral circulation has in these cases been opened up previously. As a matter of fact, at any rate in young and healthy people, the ligature of the main vein with the artery for wounds of both vessels does not seem to add to the risk of gangrene, but rather to diminish it, and this by reducing the venous congestion in the limb; but whether this holds good for elderly people where arteries have to be tied for aneurisms is another question.

FIG 30.—GANGRENE OF FINGER DUE TO STRANGULATION BY WEDDING RING.

Gangrene is also caused by the strangulation of organs, either within the body, as in a strangulated hernia, or outside of it, as when a ligature is tied round the base of the penis, or a tight ring constricts a finger (Fig. 30), or a bandage is applied too tightly round a fractured limb. It may even result from the swelling of a limb under a bandage, which has been originally applied with no undue tension. Collodion dressings contract on drying, and may in some situations interfere with the arterial supply of, say, the point of a finger.

Gangrene may also follow the rupture of a main artery and the consequent compression of the accompanying vein by the extravasated blood, an occurrence perhaps most frequently seen after fractures and dislocations; it is then always of the moist type. (See Chapter XX.)

Treatment varies considerably in these cases. If the parts are hopelessly injured, amputation should be performed at once, so as to

prevent the risk of infection. In some fractures and dislocations with accompanying vascular damage, it may be possible to save the limb by cutting down, turning out clots, and securing the injured vessels, whilst the bony lesion is dealt with in a suitable manner. The limb should afterwards be elevated slightly, and the peripheral segment kept warm and aseptic. Should gangrene supervene, amputation will be required, its situation depending on the character of the local lesion; if it is not of a serious nature—*e.g.*, a clean fracture or simple dislocation—it is wise to wait for a line of demarcation; but, if comminution of bone or other grave local trouble is present, one should amputate above the injury.

(*b*) **Direct Traumatic Gangrene,** resulting from the immediate effect of injury to the parts, is similarly due to a variety of lesions.

(i.) **Severe crushes or blows** are a common cause of this type of gangrene; thus a limb may become mangled between the wheels of machinery, or by heavy weights falling on it, or by the passage of vehicles over it. Not only are the parts crushed, severely contused, or even 'pulped,' but the bloodvessels may be torn, and the pressure of extravasated blood contributes to the result. The gangrene is of the moist type, and is more likely to supervene in patients whose vitality is diminished. Thus, a crush of the foot in an elderly person is often followed by it, whilst in a young and healthy adult it may be prevented.

Treatment.—If the part is hopelessly damaged, operation should not be delayed, on account of the dangers of infection; and therefore immediate amputation is recommended. The question of shock and its influence in determining operation is discussed elsewhere. When there seems a reasonable chance of saving the limb, it is cleansed and purified under the strictest antiseptic precautions; should gangrene supervene, it may be removed later.

(ii.) **Prolonged pressure** is also capable of producing gangrene. Gangrene from splint or plaster pressure, though very occasionally almost unavoidable, is generally the result of carelessness. When the fragments are much displaced after a fracture, considerable pressure may be required to retain them in good position, and then in spite of every precaution necrosis may ensue. Pain of a neuralgic type is usually complained of for a few days, but even that is not necessarily severe enough to attract much attention; when the limb is freed later on, the dead portion of the skin is white, anæmic, and insensitive. The necrotic process may extend to some depth, and hence the greatest care must be taken to keep the dead tissues aseptic, thereby avoiding grave disturbance. (See also Chapter XX.)

Bedsores are likely to occur in patients who are kept for a long time in the recumbent posture, or in any one particular position. The parts most exposed to pressure become red and congested, and finally ulceration or actual gangrene supervenes. Bedsores are not usually extensive or deep; but, if the patient is debilitated or paralysed, the process may extend rapidly, destroying fasciæ, laying open muscular sheaths, and even leading to necrosis or caries of bone

(acute bedsore). The spinal canal itself has been opened in this way, and death from infective meningitis has resulted. To prevent the occurrence of such sores, the nurse must see that the draw-sheet and bed-linen are placed smoothly and without creases, and that no contamination by urine or fæces is allowed. The skin of the back is daily washed with some non-irritating soap, and rubbed with a soothing and hardening application, such as methylated spirit, or a mixture of brandy and white-of-egg, or painted with an alcoholic solution of picric acid. It is then dusted over with a powder, consisting of equal parts of oxide of zinc, boric acid, and starch, in order to harden and dry it. If the skin becomes red, it should be painted with a mixture of equal parts of tincture of catechu and liquor plumbi subacetatis, which when dry leaves a powdery film on the surface: and protected from pressure by a water-pillow ring. Paraplegic patients or old people should be placed on a water-bed, which must be sufficiently, but not excessively, distended. If there is too little water, the weight of the body displaces it unduly, and no good results; whilst if there is too much, the bed becomes hard and resistant, and fails in the object for which it is employed. When an open sore forms, fomentations are required in the more acute stages, whilst later it may be dressed either with diluted boric acid ointment, or in the more sluggish cases with resin and boric acid ointments mixed. Compound tincture of benzoin (Friar's balsam), mixed with castor-oil (1 part of the balsam to 7 of the oil), is useful in this condition.

III. Gangrene from Physical and Chemical Causes.

1. **Frost-bite.**—This condition is not often seen in this country, but by no means uncommon in regions where the winter is colder, and is induced more readily if a high wind is blowing, the heat of the body being thereby quickly lost. Children and old people are more likely to be attacked, as their vital powers are less marked than in adults. It originates in one of two ways:

(*a*) From the direct effect of cold on the tissues, which become shrunken, hard, and of a dull waxy appearance. No pain is experienced in the freezing process, so that onlookers are more likely to recognise the condition than the individual himself. The extremities of the body, where the circulation is sluggish, and exposed parts, such as the nose and ears, are chiefly liable to be attacked. Gradually the part shrivels, turns black, and is either absorbed or separated by a process of ulceration, with or without suppuration. A feature of gangrene from frost-bite is the more extensive implication of the superficial tissues on account of their greater exposure (Fig. 31).

(*b*) From the subsequent inflammation in parts which, though frozen, are not immediately killed. The thawing of these structures is accompanied by severe pain, and the prolonged cessation of the

circulation in the affected part so depresses the vitality of the vessel-walls that the re-admission of the circulating blood is likely to be followed by an acute inflammation, which terminates in necrosis from compression of the vessels by the rapidly formed exudate. If it escapes actual death, the part remains red, congested, and painful for some time, and superficial ulcers may even develop; eventually, however, it recovers.

FIG. 31.—GANGRENE FROM FROST-BITE.

Treatment.—The frozen parts must be thawed very gradually, and the blood admitted into the tissues slowly, if inflammatory gangrene is to be avoided. They should be gently rubbed with snow or cold water, and warmed by being held in the hands of the manipulator, whilst the patient should be placed in a cool room, the temperature of which is slowly raised. As reaction comes on, a small amount of warm drink may be cautiously given. Excessive pain or congestive œdema may be limited by elevation of the part. If actual gangrene occurs, the dead tissue must be rendered and kept aseptic, and the case carefully watched until a definite line of separation has formed.

Indians, lumbermen, prospectors, etc., in North-West Canada, where frost-bites are common, have found that oil of turpentine is the best application in all stages. The parts are kept soaked with the fluid, and the results as reported are phenomenal.

2. **Burns and Scalds.**—These may be considered as a special variety of wound, not necessarily ending in gangrene, brought about by the action of heat; burns, either by the close proximity to, or direct contact with, flame or heated solid bodies; scalds, by the action of boiling water, superheated steam, or other hot fluids or gases, the difference in the effects being comparable to the distinction between roasting and boiling. Naturally, fluids such as oil, which boil at a higher temperature than water, produce increasingly severe results.

Six different degrees of burn were described by Dupuytren, and his classification may still be retained with advantage.

The **first** degree consists merely in a scorch or superficial congestion of the skin, without destruction of tissue; the part may, however, remain red, painful, and prone to ulceration for a time. Should the scorch be often repeated, as by people constantly warming their legs before the fire, the skin becomes chronically pigmented and indurated (erythema ab igne).

In the **second** degree the cuticle is raised from the cutis, and a bleb or blister results. When this bursts, and the cuticle is removed, the cutis vera, red and painful, is exposed below. Permanent discoloration may follow this lesion.

In the **third** degree the cuticle is destroyed, as is also part of the cutis vera, but the tips of the interpapillary processes, including the exquisitely sensitive nerve terminals, are laid bare and left intact; consequently this is a most painful form of burn. The deeper structures of the skin—*viz.*, the sweat and sebaceous glands, and the hair follicles—are not destroyed, so that, although the surface during the healing process becomes covered with granulations, the integument is very rapidly replaced, since there are so many epithelial elements from which it can grow. The cuticle is able to form, not only from the edge, as must occur wherever the whole of the cutaneous envelope is destroyed, but also from innumerable foci scattered over the wound-surface. The resulting scar, though often white and visible, undergoes no contraction: it is supple and elastic from containing all the elements of the true skin. Burns due to the sudden generation of heated gases, such as the explosion of shells or bombs, or the bursting and ignition of a petrol-tank, are often of this type, and with careful treatment which conserves any undestroyed portion of epithelium excellent results are often obtained; the face, neck, and hands are usually the parts chiefly involved.

In the **fourth** degree the whole thickness of the integument is destroyed, as well as part of the subcutaneous tissues. In the **fifth** the muscles are also encroached upon, whilst in the **sixth** the whole limb or other affected part is completely charred and disorganized. In the last three forms healing can occur only by removal of sloughs and the formation of a cicatrix, which by its contraction may lead to deformity.

The **Local History** of a burn may be described in three stages, corresponding to the three stages through which an ulcer or a lacerated wound passes: (1) **The stage of destruction or burning,** the various degrees of which have been just described; (2) **the stage of inflammation and sloughing**, whereby the dead tissue is removed, and the wound converted into a granulating sore; (3) **the stage of repair.** There are no special characteristics of these processes which call for particular note, except that they are almost always associated with infection, unless the burn is a small one. The skin is generally dirty (from a surgical standpoint) at the time of the accident; it may be infected from the clothes which are being worn, and immediate attention may be impossible. Moreover, the extent of the lesion and the terrible pain caused by it often render complete sterilization impracticable.

The **General or Constitutional Conditions** which correspond to these three stages also require notice.

1. In the early stages **shock** is usually present, and its intensity depends as much on the extent of the burn as on its depth, so that

total charring of a limb may cause less depression of the system than an extensive superficial scorch, especially if the latter involves the abdomen or the head and neck. It frequently passes into a condition of collapse, due in large measure to the absorption of toxic products from the burnt tissues.

2. Subsequently a period of **inflammatory fever,** usually of infective origin, follows, and may last for four to fourteen days. The viscera become congested, particularly the gastro-intestinal canal, liver, lungs, and brain, and various complications may result therefrom.

One of the sequelæ frequently described, though at the present day it is admittedly very uncommon, is Ulceration of the Duodenum. The ulcer is of the usual duodenal type, but occurs close to the orifice of the bile-duct. It probably results from the elimination by the liver of some irritating substance derived from septic changes in the burnt tissues which is capable of inducing thrombosis, or of producing ulceration. In one case under observation, a post-mortem examination revealed a patch of well-marked ecchymosis in the duodenal mucosa exactly opposite the orifice of the bile-duct. Obviously it was the early stage of this condition, and would have gone on to ulceration had the patient lived. For clinical phenomena, see Chapter XXXVIII.

3. When healthy repair is occurring locally, no abnormal constitutional condition should be present. If, however, the wounds are septic and suppurating freely, the patient may develop a hectic temperature and even die of exhaustion.

Causes of Death from Burns.—If an individual is burnt to death, the fatal event is usually occasioned by asphyxia from the smoke and noxious fumes of the fire, or by shock and syncope. Within the first few days death results from toxæmia; in the second stage, from infection; in the third stage, from exhaustion or intercurrent maladies. The prognosis in children is always more unfavourable than in adults.

Treatment.—In the treatment of burns it is essential that any application should be painless, and should prevent toxæmia due to the absorption from the injured area of toxins resulting from protein disintegration. Also the application should prevent a burn from becoming deeper. For instance, application of picric acid will often produce third degree burns from a second degree, because every time a new dressing is applied some of the epithelium adheres to the dressing, and so the wound becomes deeper.

The ideal treatment of burns should consist of: (*a*) A painless dressing, so that the initial shock is not increased; (*b*) it should prevent any absorption of toxins from the injured tissues; (*c*) it should prevent any sepsis in the wound; (*d*) it should encourage rapid healing.

A solution of tannic acid (2·5 per cent.) sprayed on to the burned area is the only substance which will in any way come into line as the ideal in the treatment of burns and scalds. Perhaps its greatest advantage over the other solutions is the fact that it prevents the

absorption of toxins, which are generally the cause of death during the second and third days after the injury. The treatment is painless, and after the tanned eschar has separated, the underlying granulation tissue is quite healthy, free from sepsis, and in a good condition for skin grafting, should this be thought desirable. There is no changing of dressings, and therefore no trauma to the tissues, and the burn therefore tends to heal, and not to become deeper and more painful.

The actual treatment consists in treating the initial shock by a hypodermic injection of morphine. The skin is cleansed with ether, and particles of dirt or débris are removed with sterile forceps. A freshly-prepared 2·5 per cent. solution of tannic acid in water is sprayed over the wound, and the patient is placed in bed on a clean sheet without any clothes or dressing of any kind. A warm tent is made with blankets covering a large cradle, on which are fixed one or two electric lights, which, besides providing warmth, also promote drying of the tannic acid solution. The burnt area is sprayed every half hour until a dry brown crust has formed which completely seals the wound. This is usually obtained from fifteen or twenty-four hours after the commencement of the treatment. It is very essential to give plenty of fluids to prevent concentration of the blood. The patient will generally take fluids by the mouth, but this is not sufficient. Extra quantities of fluids are administered by hypodermoclysis and proctoclysis, and in the worse cases blood transfusion may be necessary. As a rule, by the third or fourth day all evidence of toxæmia has completely disappeared, and in second degree burns the crust begins to loosen and the epithelium proceeds to grow in from the margin of the wound. In burns of the third degree the crust may take two weeks to loosen, and on removal a clean granulating surface is exposed which will require skin grafting if its area is large, so that scar formation can be reduced to a minimum. Where the area is small the granulation tissue is soon replaced by new epithelium which has grown in from the edges of the wound. Since this treatment has been adopted the period of rest in bed has been considerably reduced.

There are a few points which require to be emphasized: The solution of tannic acid must be freshly prepared, because if it is left in solution it is converted into gallic acid. Great care must be taken to clean up the burnt area prior to the application of the tannic acid. All blisters should be opened, and the overlying epithelium removed. The application of the tannic acid solution should be given at regular half-hourly intervals. If these details are carried out the results are excellent.

For burns on the face, including the eyelids, an ointment of tannic acid can be used instead of the watery solution.

In many bad cases Thiersch or pedicle-grafting may be employed with advantage, especially in the flexures of joints, though the necessity for this has diminished since the tannic acid treatment was initiated. Great care must be taken, of course, to prevent de-

formities whenever possible; in a burn involving the axilla, the arm must be kept out at right angles; in one involving the elbow, it must be kept straight, and in deep burns of the limbs daily movements of the joints must be undertaken early to prevent adhesions; one full range of movement *per diem* will suffice.

The action of **corrosive or caustic chemicals** is followed by a localized traumatic necrosis, the degree of which varies with the amount and character of the irritant present, and the duration of its action. All that is needed is to keep the parts aseptic, and allow them to be absorbed or separated by natural processes.

Such necrosis occasionally follows the application of a carbolic acid compress, even when weak solutions—*e.g.*, 1 in 60—are employed. The fingers are the parts usually affected, and the necrosis does not seem to be due to tight bandaging, or to the presence of a waterproof covering. Carbolic acid is readily absorbed through the skin, and probably acts by directly poisoning the tissues.

IV. Acute Infective Gangrene.

(*a*) **Acute Spreading, Acute Emphysematous, or Spreading Traumatic or Gas Gangrene.**—This disease is one of the most rapidly fatal met with in surgery.

Causes.—(i.) The individual attacked is often debilitated as a result of the hardships of military service, or of vicious or careless living, heavy drinking, or simple malnutrition; but even healthy individuals may be attacked if the virus is active. It is sometimes seen in diabetics, but a non-diabetic toxic glycosuria occasionally develops in the course of the disease itself.

(ii.) The causative lesion is usually severe, such as a compound fracture or dislocation, especially if the soft parts are much contused or very dirty. Defective purification of such tissues, and injudicious attempts to save them by accurate and close stitching, perhaps without drainage, are amongst the most frequent predisposing causes of this complication. Less commonly it follows a small and insignificant prick, scratch, or abrasion, through which a highly virulent organism gains access to the tissues.

(iii.) Such cases are usually **mixed infections,** various anaërobic organisms from soil, fæces, etc., being found along with the usual staphylo- and strepto-cocci, etc., of wound-infection. The anaërobic organisms most commonly present are, in order of frequency, *Bacillus welchii*, *B. œdematis maligni*, and *B. œdematiens*. *B. welchii* (*B. aerogenes capsulatus* or *B. perfringens*), much the most important of these organisms, is an anaërobe with a well-defined capsule and non-motile; it rarely forms spores and is Gram-positive. It has the power of fermenting sugar if grown in a medium containing carbohydrate, *e.g.* glucose, and produces a large quantity of gas both in the tissues, especially the muscles, and, especially after death, in the blood within the vessels; on post-mortem examination an abundance of gas can be squeezed from the liver, which may show innumerable

small, apparently 'empty' sponge-like gas-filled cavities in its substance, occasionally produced before death, but most commonly a phenomenon of decomposition occurring at or after death. *B. œdematis maligni* (*Vibrion septique* of Pasteur) is a similar organism, Gram-positive when young, and actively motile; it develops only under strict anaërobic conditions, and produces also an abundance of foul-smelling gas when glucose is present in the culture-medium. Its inoculation into mice and guinea-pigs is followed by their death within twenty-four hours, preceded by a spreading œdematous condition of the connective-tissue spaces containing multitudes of the bacilli and perhaps gas.

Symptoms.—The active outbreak of this disease may be delayed for two or three days after the occurrence of the wound, during which time the latter is perhaps a little painful, but shows no special signs of activity; none the less, mischief is going on out of sight, and the absence of discharge is a bad sign. In some cases the period of incubation is shorter. Suddenly, and perhaps with little warning, the case develops as a hyper-acute cellulitis, accompanied by general septicæmia. The wound, when opened up, is found to be unhealthy, the surface covered with sloughs, and a thin serous or sero-purulent discharge escaping. The inflammatory process rapidly spreads along the connective-tissue planes, and especially in the substance of the muscles, *e.g.* of a limb, which becomes swollen, painful, and brawny. In one case under observation the gangrene spread from the foot to the groin within twelve hours. At first the parts show a bright red blush, but they soon become purple, gangrenous, and crepitant. The emphysema spreads widely and rapidly, with at first no other local signs; sloughing will, however, follow if the patient live long enough. Evidences of profound toxic disturbance, such as hyperpyrexia and delirium, soon manifest themselves; but not uncommonly fever may be entirely absent, the temperature being subnormal and coma present. The outlook is exceedingly grave, death usually ensuing in two or three days.

Treatment.—It is impossible to emphasize too strongly the danger of closing up completely and without drainage lacerated and contused wounds which have been caused on the battle-field, or by accidents on the railways or in the street, whereby the damaged tissues have been brought into contact with the ground, and perhaps infected thereby. Dangerous anaërobic organisms are so constantly present in the soil, that to close up such a wound is to favour their development. Prophylactic injections of anti-tetanus serum should be given in all such cases; and it is probable that antisera specific against *B. welchii* and similar anaërobes, if available, will be helpful if used immediately such infections are diagnosed. Scrupulous antiseptic cleansing of the wound, accompanied by the removal of dead and damaged tissues (as in military surgery), followed by the application of B.I.P.P., loose suturing of the parts, and free drainage, are essential if dangerous consequences are to be avoided. The appearance of

inflammatory phenomena will necessitate free opening of the wound, followed by incisions through infected tissues and immersion of the limb in a warm bath containing eusol or weak iodine solution. If, in spite of this, the disease spreads, a high amputation, well above its upper limits, even through the shoulder or hip-joint, is the only hope of saving life.

(*b*) **Wound Phagedena and Hospital Gangrene** were very common in the pre-antiseptic era, but are now practically unknown. They consisted in a rapidly spreading ulceration or gangrene, which attacked operation-wounds a few days after their infliction, and as a rule led to rapid death.

(*c*) **Cancrum Oris and Noma.—Cancrum oris** is an infective gangrenous stomatitis, affecting especially young children living in squalid surroundings in over-populated districts of large cities. The patients are always in a low state of health, and frequently convalescing from one of the exanthemata, particularly measles. The process starts in an abrasion of the mucous membrane, which, being infected, perhaps from a diseased or dirty tooth, becomes inflamed and gangrenous. A foul ashy-gray pultaceous slough forms on the inside of one of the cheeks, and from this a most offensive discharge is poured into the mouth and swallowed, the breath in consequence becoming intensely fœtid. The gangrene gradually spreads both superficially and deeply; the cheek becomes swollen, shiny, and tense, and, should the process extend through its whole substance, a black slough appears on its outer aspect. In bad cases the adjacent bones of the face may be affected and die, and the tongue, palate, and even the fauces, may also be involved.

The general phenomena are those of a severe toxæmia, since not only are the toxic products swallowed, but they are also absorbed by the lymphatics, and may be inhaled, in the latter case giving rise to septic broncho-pneumonia. Moreover, the patient runs a considerable risk of developing pyæmia, from implication of the facial or other veins in the necrotic process, whilst septicæmia may also supervene. Rigors and high fever may occur early in the case, but death is usually preceded by symptoms of collapse and coma, with a subnormal temperature.

The **bacteriology** of this affection is still doubtful. Enormous numbers of mixed organisms are present, but of these probably the most important is the *Streptococcus pyogenes*, perhaps in conjunction with a fusi-spirochætal (Vincent's) or other infection.

The **Treatment** must be prompt and energetic if the child's life is to be saved. The patient should be anæsthetized, and all the pultaceous slough removed by cutting or scraping, until healthy bleeding tissue is reached. The denuded surface is then freely rubbed over with pure carbolic or strong nitric acid. In using such agents, the throat must be carefully protected, and the excess of acid in the case of the former dissolved by spirit, and in the latter neutralized by bicarbonate of soda. If the bones of the face are involved, they must be removed, as also any offending teeth. Afterwards the

mouth is to be washed out frequently with antiseptic lotions, such as a solution of peroxide of hydrogen (1 in 10), sanitas (1 in 10), boro-glycerine (1 in 20), or permanganate of potash. The child must be given plenty of suitable fluid nourishment, and, if need be, stimulants. In the most severe cases, the whole thickness of the cheek may be encroached on; loss of substance must be made good by subsequent plastic work. Necessarily, the cicatrization following this destructive process results in considerable permanent impairment to the movements of the jaw.

Noma is the name given to a similar process occurring about the genital organs of children, especially the vulva. The **Treatment** is practically the same, except that here it is possible to immerse the patient in a warm antiseptic bath of potassium permanganate, after having removed the infected tissues.

CHAPTER VII.

SPECIFIC INFECTIVE DISEASES.

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Erysipelas.*

ERYSIPELAS is a contagious infective disease almost always, in the human subject, due to the development of one of the various strains of *Streptococcus pyogenes* in the smaller lymphatics of the skin and occasionally of mucous membranes, with a decided tendency to spread and to recovery without loss of tissue, the constitutional symptoms being due to the absorption of toxins developed locally. Occasionally the subcutaneous connective tissue is also involved, constituting the variety known as **cellulo-cutaneous erysipelas.**

The **Causes** of erysipelas may be briefly stated as follows: (i.) The existence of an abrasion or wound in most cases, and particularly of an unprotected dirty wound. Thus, it is not uncommon to find it associated with neglected scalp-wounds or with those communicating with the mouth. The wound may be very minute, such as a prick or scratch, or there may be no obvious wound at all, infection occurring, perhaps, through a hair follicle in healthy skin. The organisms may in some cases lie latent in the tissues for considerable periods of time, and only be stimulated to activity by some fresh injury. (ii.) A weak, depressed state of the constitution, as from alcoholism, deficient or bad food, vicious living, diabetes, albuminuria, etc. Some people, moreover, seem naturally predisposed to the disease, particularly plethoric and gouty individuals, and one attack renders the subject more liable to recurrence after a short period of immunity. (iii.) Bad hygienic surroundings are an important additional factor in its production, especially overcrowding in hospitals and defective ventilation. But these are all merely predisposing conditions; the only specific exciting cause is—(iv.) infection with the particular micro-organism.

The **Symptoms** of the disease usually commence with headache and malaise, followed, in about twenty-four hours, by a slight rigor, well-marked pyrexia, and the development of the rash, spreading either from the margin of the wound, or showing itself in apparently unbroken skin in the so-called 'idiopathic' variety. If there is a wound, it usually presents a yellowish, unhealthy-looking surface,

* It is becoming more than ever doubtful whether erysipelas is to be looked on as a *specific* infection. Careful bacteriological examination is indicating that other pyogenic organisms than the streptococcus may occasionally be responsible for its appearance, and it is probable that hereafter we may have to relegate it to the chapter dealing with non-specific infections.

with very little evidence of repair. In such a wound, when the infection is an unmixed one, the healing process may continue until the rash appears on the third or fourth day, when the young cicatrix will break open again, exposing a dry and sluggish surface with a thickened margin. The rash is generally of a characteristic vivid rosy-red colour—whence the popular name 'the rose' for the condition—disappearing on pressure, and accompanied by a sensation of stiffness or burning, scarcely amounting to pain, except when dense structures, such as the scalp, are involved, and then the pain may be severe. Swelling is not marked, except in lax areolar tissues, such as in the scrotum or eyelids; the œdema may then attain considerable proportions. In a typical case, the rash continues to advance more or less rapidly, with an abrupt continuous slightly raised margin, and as it spreads to new regions it fades away from those already involved, leaving a slight brownish pigmentation and a fine branny desquamation. In some cases it does not spread regularly, but appears to leap over an interval, the infection having travelled by the intervening lymphatics, which are found to be thickened. Vesicles and bullæ may form superficially, containing serum, which speedily becomes turbid, but suppuration is uncommon, except in lax œdematous tissues such as those of the eyelids. Occasionally, from the severity of the inflammation or the low state of vitality of the tissues, the skin may become gangrenous and slough, especially about the umbilicus and genitals of young children. Neighbouring lymphatic glands are always enlarged and painful, and this may be noted even at a period when the rash has not appeared. Periphlebitis may also be caused, and may lead to thrombosis and perhaps pyæmic complications. Fever is present as long as the rash persists, and shows merely slight diurnal variations. It is not uncommon for the temperature to reach 104° F., but any rise above that is of grave significance. At first the fever is of a sthenic type, the pulse full, and the delirium noisy and active; but later the pulse becomes quick and weak, accompanied by low, muttering delirium and great prostration. Leucocytosis is moderate in degree (15,000 to 20,000 leucocytes per cubic millimetre). The duration of the attack is very variable, lasting, as a rule, from one to three weeks, but relapses are not uncommon. The swelling of the part does not always clear up entirely, owing to persistent blocking of lymphatics; when repeated attacks occur, this swelling may become so great as to simulate a form of elephantiasis.

The so-called **Idiopathic Erysipelas** affects particularly the head, and occurs in predisposed individuals, often recurring about the same time of the year; pain and delirium are prominent symptoms, and the subcutaneous tissue of the face becomes so swollen that the features are almost unrecognizable. Large blebs form, and abscesses are not uncommon about the eyelids.

Cellulo-cutaneous Erysipelas, as already stated, is due to infection of the subcutaneous tissues, as well as of the skin, with the specific virus, and results in suppuration and perhaps sloughing both of the skin and

subjacent cellular tissue. To the ordinary phenomena of erysipelas is added a diffuse infiltration of the subcutaneous tissues, brawny at first in type, but subsequently softening and becoming boggy, the skin finally giving way, and allowing exit to the pus and sloughs. The general symptoms are correspondingly severe, and pyæmia may supervene. As distinguishing features from ordinary erysipelas, it is stated that the margin of the redness is less defined, and that the lymphatic glands are less enlarged.

Erysipelas of the Scrotum is characterized by the part becoming greatly distended by serum, but without any marked redness. Suppuration and sloughing are not unlikely to follow. It thus somewhat simulates the appearance produced by extravasation of urine, but is distinguished from it by the facts that micturition is usually not interfered with, and that the swelling is not limited in the same way as in the latter affection.

Pathological Anatomy.—On microscopical section of the affected skin, colonies of cocci arranged in chains will be found invading the lymphatics just beyond the spreading margin, whilst in the inflamed area there is a considerable excess of leucocytes, blocking the lymphatics, and evidently engaged in the destruction and removal of the cocci, since phagocytic inclusion of the organisms is frequently observable. The lymph-glands will also be found enlarged and congested. Fatal cases show merely the ordinary post-mortem signs of death from a general toxæmia or septicæmia (p. 95).

Diagnosis.—There is not much difficulty in recognizing a case of erysipelas, if the distinguishing features of the rash are remembered, *viz.*, its method of extension by a broad, sharply-defined, slightly raised and infiltrated red margin, and its almost invariable association with superficial vesicles, perhaps visible only on examination with a lens, or with obvious pustules or bullæ. An infected wound with pent-up discharge closely simulates erysipelas; but the redness has not such an accurately defined margin and does not spread beyond the immediate neighbourhood of the wound; cutaneous vesicles are not usual in ordinary sepsis, whilst lymphatic enlargement is uncommon. A patch of cellulitis will also be distinguished by the same features.

Prognosis.—Erysipelas is not peculiarly dangerous in itself (Osler gives the death-rate as 7 per cent. in hospital patients), but may become so from the complications. The most important of these are inflammatory conditions of the brain, lungs, and other viscera, especially of the kidneys. Erysipelas is usually attended with danger to life in old people, drunkards, and infants, whose vital powers become rapidly exhausted. It is interesting and important to note that, after an attack has passed, the tissues of pre-existing wounds, even if the latter have been previously chronic and sluggish, often manifest markedly increased reparative power, provided no other complication is present. Chronic tuberculous (*e.g.*, in lupus) and syphilitic ulcers may also rapidly cicatrize, and

even malignant sores, especially sarcomata, have been reported to have been cured.

Treatment.—Erysipelas is a notifiable disease under the Infectious Diseases Acts, 1889 and 1899, and the patient must be isolated or removed if possible from a surgical ward. If unfortunately this is impracticable, the patient must be placed as far away from others as possible, and especially from those with open wounds, which from their position (*e.g.*, the mouth) cannot be properly protected from infection. It is wise under these circumstances to put off all operations that can be safely postponed; the bed should be surrounded with sheets kept moist with carbolic lotion, and the floor around sprinkled with the same. Special nurses and dressers must be told off to attend to the case, which should never be dressed with ungloved hands. Midwifery cases especially must be most scrupulously protected from infection at the hands of nurses and doctors in charge of cases of erysipelas.

Local Treatment has for its object the protection of the affected part from the air, together with relief of tension and pain, whilst at the same time the local resistance of the affected tissues is conserved. A sticky preparation such as a 20 or 40 per cent. aqueous solution of ichthyol (or of its artificial substitute, thiol), or a 10 per cent. ointment of ichthyol, applied continuously, effects these objects and also prevents the diffusion of dried scales from the skin, which presumably contain the virus. A 20 per cent. solution of subitol is also much advised, or a saturated solution of sulphate of magnesia, from which crystals of the salt form on the skin; the latter is specially useful where there is much pain. If these preparations are not obtainable, fomentations of opium or belladonna (*e.g.*, laudanum 1 ounce, to lotio plumbi, 1 pint) are helpful.

In cellulo-cutaneous erysipelas early and free incisions must be made to relieve tension, and, if possible, anticipate suppuration. The tissues, when incised, look gelatinous from the œdema present, and much fluid of a sero-purulent type will escape. Antiseptic fomentations or hypertonic applications should be employed after the incisions have been made, until granulations have developed.

Constitutional Treatment must be of a tonic and supporting character. Good food, easy of assimilation, and quinine should be freely administered, whilst the tincture of the perchloride of iron in ½-drachm doses, repeated three or four times a day, is still looked on by many as a specific. The latter drug must be combined with salines or purgatives, so as to avoid constipation. Collosol manganese is apparently of considerable value in doses of ½ to 3 c.c. administered intramuscularly every two or three days according to the temperature. Antistreptococcal serum (p. 25) should be employed as early as possible, 30, 50, or 100 c.c. or even more of the polyvalent serum being given—the smaller doses intramuscularly and repeated if necessary every six hours: the larger intravenously, once or even twice a day. The results have in the past, however, not been as satisfactory as it was originally expected, perhaps

partly, at all events, on account of the use of insufficient amounts of the serum; whilst some writers advise the injection of the serum locally into the affected tissues themselves. Carefully graded doses of streptococcal vaccine, preferably autogenous, beginning with a small dose of, say, 1 million organisms, should also be employed.

Diphtheria.

Diphtheria is an infectious disease due to *Bacillus diphtheriæ* (or Klebs-Löffler bacillus), which is a non-motile organism about 3 or 4 μ in length (Plate I., Fig. 7). It grows on all ordinary culture-media, but most readily in the presence of blood-serum. It is Gram-positive, and often stains unevenly, and, especially if the films are made from a young serum culture, typical metachromatic granules may be demonstrated by appropriate staining methods. The disease usually involves the mucous membranes, particularly those of the pharynx, larynx, and nasal cavities; occasionally it attacks open wounds, the skin, conjunctiva, and the genitals. It is characterized by a fibrinous exudate, closely incorporated with the degenerating or necrotic superficial layers of the tissues affected—the so-called diphtheritic ' false membrane '—so that attempts to remove it cause slight bleeding. The toxins developed in the lesion produce a special type of toxæmia. The infection may be transmitted directly by the discharges, or indirectly, as in milk. The bacilli may occasionally be found in a virulent condition in the throats and nasal fossæ of apparently healthy individuals, who act as ' carriers,' and may thus lead to outbreaks of the disease without obvious cause.

The identification of the bacillus is not always possible microscopically in direct films from the lesion, and the **laboratory diagnosis** depends chiefly on its successful cultivation on blood-serum. Moreover, other organisms (diphtheroids) exist which simulate it closely, but are comparatively harmless. Expert investigation, microscopical, cultural, and in some cases by animal-inoculation, is required in order to differentiate true virulent and pathogenic *B. diphtheriæ* from these, and also from non-virulent and apparently harmless strains of *B. diphtheriæ* itself, both forms being found in so-called carriers. If the throat is to be examined, the patient should be placed in a good light, and, if a child, securely held. The tongue being depressed, a sterile throat-swab is firmly rubbed over any visible membrane, actual portions of which should, if possible, be removed upon it, and the swab replaced and immediately sent to the laboratory. The operator must always be on his guard lest the patient cough pieces of membrane, etc., into his face during the operation.

The *Schick reaction* is of great value in demonstrating whether an individual is susceptible or not to this disease, *i.e.* whether or not the blood contains antitoxin, since the immunity associated therewith is purely antitoxic and not necessarily permanent. A minute dose of the toxin is injected into the skin of the arm, and if the recipient is susceptible a positive reaction develops in twenty-four to forty-eight hours, consisting of redness and slight infiltration, which reach their maxima on the third or fourth day and then disappear, leaving a scaling area which remains pigmented for three to six weeks. The severity of the reaction indicates the degree of susceptibility. If there is

no reaction, the person is presumably immune to the disease, although it is still possible that he may be a carrier of virulent bacilli in the nose or throat A *pseudo-reaction* sometimes develops in response to the foreign proteins in the material injected; this appears in eight to sixteen hours as an urticarial blush, reaching its height in thirty-six to forty-eight hours and disappearing on the third or fourth day. For the detection of this pseudo-reaction, a control is carried out on the opposite arm, with a similar amount of toxin previously heated to 75° C. for five minutes, which destroys the specific action of the toxin, but not the substances causing the pseudo-reaction.

It has been demonstrated by this means that some 80 per cent of new-born infants are practically immune, the protection being of passive origin and probably derived from the mother's blood or milk. This immunity is, however, usually transient, and by two years of age 70 per cent. are susceptible, a figure that tallies with the clinical observation that the disease occurs mainly in children of from one to four years of age. By five to ten years of age only 30 per cent. are found to be susceptible, and the figure falls to about 20 per cent. when adult life is reached.

Prophylactic inoculation consists in the injection of suitable doses of toxin and antitoxin, mixed so that the toxin is not quite fully neutralized; 1 c c is injected, and the dose is repeated thrice at intervals of a week. There is usually little or no reaction in infants (the procedure is best carried out in children from about a year old), but older children and adults are liable to develop a reaction of some severity The protection thereby provided is often permanent.

In institutional work amongst children, these methods of investigation and immunization have proved most valuable

The serious feature of an attack of diphtheria is the absorption of the diphtheria toxin, for the bacilli are almost always localized. The toxin is an exotoxin, and not only causes fever, but also produces neuritis of motor nerves, thereby producing paralysis. This is most often shown in the palatal, orbital, and ocular muscles, but may affect the muscles of the trunk and limbs. Cardiac weakness is common, and is due partly to degeneration of muscle, and partly to action on the vagus. The toxin has considerable poisonous effect on the kidneys, and albuminuria is common.

The characteristics of pharyngeal and laryngeal diphtheria are described under their respective headings.

Treatment.—The most important point is the administration of antitoxic serum in doses of from 8,000 to 50,000 units* or more, given intramuscularly or intravenously—the latter route being chosen in the more urgent cases, and the dose repeated if no improvement within twelve or twenty-four hours ensues. Children require as large doses as, or even larger doses than, adults. The subcutaneous route may be used to supplement either of the other two, or when the serum is given as a prophylactic measure. The value of the treatment depends largely on the promptitude with which it is applied, the mortality from diphtheria being practically nil among patients who receive antitoxin on the first day of the disease, and rising steadily with delay. In all cases where there is a reasonable probability that the infection is diphtheritic, serum should, therefore, be administered immediately, and without awaiting the result

* The unit is the amount of antitoxin which will neutralize 100 times the minimum lethal dose of toxin required to kill a guinea-pig of 300 grammes in four days.

of the cultural bacteriological examination. In addition, local antiseptics are useful, and in laryngeal cases, where dyspnœa occurs from obstruction of the larynx by membrane, tracheotomy or intubation may be necessary. Attention must also be given to the results of secondary infection with streptococci, etc., if present.

Tetanus.

Tetanus is a local infective disease, due to *Bacillus tetani*, associated with a characteristic toxæmia. The bacillus occurs in the form of delicate straight rods, which sometimes grow into long threads. It is a strict anaërobe, and usually develops a characteristic spherical terminal spore, giving it the appearance of a drumstick (Plate IV., Fig. 3). Such spores appear both in the pus of the wound and in cultures, and are extremely resistant to the action of heat (they usually survive boiling for at least five minutes) and antiseptics. The bacilli stain by Gram's method and possess numerous flagella. They of themselves do not tend to proliferate actively in the tissues unless the vitality of these is also lowered by the action of the toxin itself, or by the products of other bacteria, or the presence of a foreign body such as a splinter of wood, earth, etc., or by other damage to the tissues, *e.g.* the fracture of bone. When separated completely from their toxins the spores often fail to produce tetanic symptoms, even when injected into susceptible animals; should, however, a minute trace of toxin be present, it so depresses the vitality of the surrounding tissues that the spores develop into bacilli which then continue to proliferate and produce more toxin.

Ætiology.—The causative organism is a facultative saprophyte, and is almost constantly found in garden soil, and street, stable, and road refuse. Those, therefore, who are brought in contact with the ground—*e.g.*, gardeners and agricultural labourers—are specially liable to the disease, particularly if the soil has been persistently and heavily manured. Horses, also, are very susceptible to tetanus, and the bacilli are usually present in their fæces; hence stablemen and others engaged in looking after horses are attacked with comparative frequency. The disease is more often seen in the tropics than in other climates, probably owing to the heat favouring the development and virulence of the organisms in the soil. The shattering and disruptive effect upon the tissues of modern artillery and high explosives explains the frequency of this affection in military surgery, whilst the difficulties connected with sanitation and washing in warfare add to the risks.

The existence of a **wound** can almost always be demonstrated, and it is usually of a dirty, lacerated or punctured character, and suppuration is generally present. Any part of the body may be thus affected, but perhaps those regions, such as the sole of the foot or the palm of the hand, which are liable to be brought into contact with the soil are most often involved. Street and road accidents are only too likely to be followed by tetanus. The depressed vitality of the tissues owing to the bruising and tearing, the irritation caused

PLATE IV.

FIG. 1.—FILM FROM BLOOD OF GUINEA PIG INFECTED WITH ANTHRAX.

The bacilli are Gram-positive and do not form spores in the living body. (Gram's Stain, × 1000.)

FIG. 2.—FILM OF ANTHRAX BACILLI FROM THREE-DAYS' AGAR CULTURE. SHOWING CENTRAL SPORE-FORMATION WITHIN THE BACILLI.

A few fully-formed oval spores are present. (Rd. Muir's Stain for Spores [Carbol-Fuchsin and Methylene Blue], × 1000.)

FIG. 3.—FILM OF TETANUS BACILLI FROM WOUND.

The typical rounded terminal 'drumstick' spores are seen on some, but have not yet developed on others, of the slender bacilli. Thicker (unidentified) bacilli, some with subterminal oval spores, are also present. (Weak Fuchsin, × 1000.)

FIG. 4.—FILM SHOWING BACILLUS COLI AND STREPTOCOCCI IN CENTRIFUGALISED DEPOSIT FROM CASE OF PURULENT CYSTITIS.

The Gram-negative *B coli* is very variable in size. (Gram's Stain, × 1000.)

FIG. 5.—BLOOD-FILM SHOWING MARKED POLYMORPHONUCLEAR LEUCOCYTOSIS FROM A CASE OF ACUTE SUPPURATION.

The red corpuscles have to some extent taken on the blue stain. Two small lymphocytes and several groups of blood-platelets are also shown in the field. No eosinophils are present. (The drawing has been made towards the end of the film, where the leucocytes were more crowded than elsewhere.) (Leishman's Stain, × 1000.)

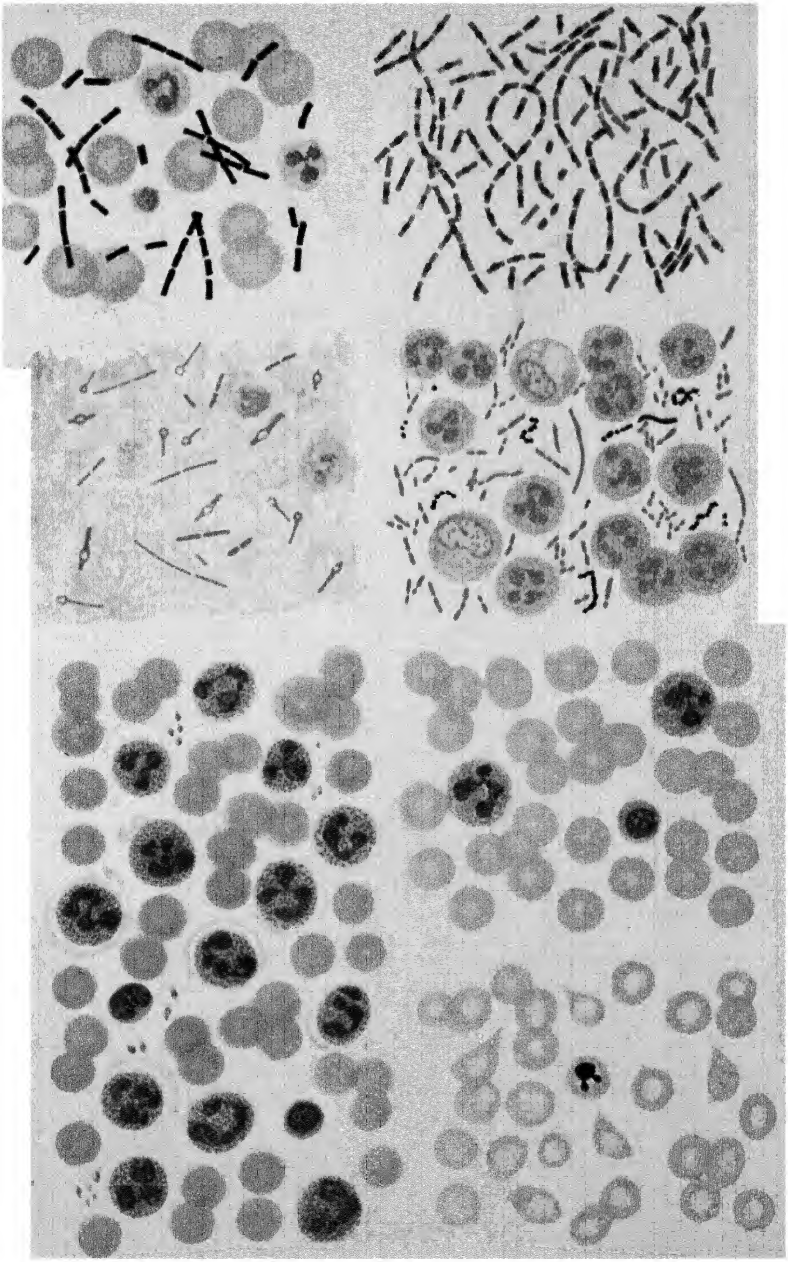
FIG. 6.—NORMAL BLOOD-FILM FOR COMPARISON WITH FIGS. 4 AND 6.

Two polymorphs and a small lymphocyte are shown along with the normal red corpuscles. (Methylene Blue and Eosin, × 1000.)

FIG. 7.—BLOOD-FILM FROM A CASE OF MARKED SECONDARY ANÆMIA IN MALIGNANT DISEASE.

The red corpuscles show irregularity in size and shape, and diminution in hæmoglobin. A normoblast with fragmenting nucleus is shown. (Jenner's Stain, × 1000.)

PLATE IV



by the growth of pyogenic organisms, and the absorption by the latter of any oxygen present, thereby determining a condition of anaerobiosis, co-operate in favouring the development of the tetanus bacilli. Hence it is rare for the disease to affect wounds where asepsis has been maintained and rapid repair has been effected, and it is very uncommon, though possible, for it to develop after blows or bruises with no breach of surface. Gunshot wounds, due to blank cartridges, are often followed by it, since the injury is largely due to the wad, which is made of coarse horsehair felt, and is therefore likely to contain spores of the bacillus. Commercial gelatin, derived from the hoofs, etc., of horses, often contains the bacilli, and the injection in the treatment of aneurisms, of this substance, when imperfectly sterilized, has been followed by this disease; and similarly the use of surgical catgut infected with spores which have escaped sterilization may cause tetanus. Occasionally the bacilli gain entrance into the tissues through trivial, *e.g.* small punctured, wounds which may heal over superficially, or in connection with lesions such as frost-bite, and they may even persist for a while in a latent condition (p. 7), developing only after an interval of some weeks or months. This is the explanation of those cases of tetanus which used to be termed 'idiopathic'—*i.e.*, where no obvious cause in the shape of a wound could be detected—and it also explains the incidence of tetanus after operations upon areas previously the site of infected wounds. Tetanus neonatorum, due to infection of the cut end of umbilical cord, was common in pre-antiseptic days.

Pathology.—Tetanus forms the best example of a local infection with general toxæmia. The bacilli remain in or near the wound, and do not enter the blood or reach distant parts of the body. The toxins produced locally act on the central nervous system in a manner very similar to strychnine, thereby increasing reflex excitability of the muscles, so that slight stimuli produce excessive muscular contractions of a tonic character.

The method of transit from a local wound to the cells of the spinal cord is peculiar in that the toxin is not absorbed by these cells from the blood or lymph, from which fluids it quickly disappears, but is picked up locally, or from the blood or lymph, by the end-plates of the nerves in the muscles, and thence is carried up along the motor nerves, either by the lymphatics or by the protoplasm of the neurons. Naturally when an infected wound involves muscles, the transference of toxin along the motor nerves of this region is facilitated, and the cells of the spinal cord controlling this area may be affected earlier than others, and so a localized form of tetanus results. It has been experimentally found possible to protect certain areas by injecting antitoxin into the motor nerves; thus if a full intravenous dose of toxin is given to an animal, and shortly afterwards antitoxin is injected into both sciatic nerves, tetanus develops in the usual manner in the head, trunk, and fore-limbs, but the hind-legs escape. Clinically, if no localizing lesion thus leads to the selection of special areas, the muscles of the jaw and neck appear to have a specific predilection

for the toxin, and it is probable that the toxin reaches the spinal cord through the nerves leading from these muscles.

The post-mortem anatomical changes are not characteristic. The muscles are often pale, or show evidences of rupture or extravasation of blood. The peripheral nerves extending from the wound may be red and congested for some distance; this may not be due to the action of the toxin (which appears to produce no demonstrable lesions of the nerves themselves), but to coincident pyogenic inflammation. The nerve-centres frequently present areas of softening and perivascular cellular exudation, with some hyperæmia, especially in the pons and medulla. Degenerative changes may also be evident in the anterior cornual nerve-cells of the cord.

Clinical History.—The **incubation period** varies from a few days to several weeks, and may be considerably influenced by the administration or not of a prophylactic dose of antitetanic serum. As a general rule in temperate climates the average incubation period of acute cases is from one to two weeks, but in the tropics the disease may appear after a few hours. The length of the incubation period is often of great prognostic value, as the later the affection appears the better the outlook, and *vice versa*; but this general statement is by no means absolute.

The **initial symptoms** are frequently somewhat indefinite and influenced also by the use of prophylactic injections. The existence of localized muscular rigidity or twitchings, or an undue reflex-response to gentle tapping or pressure of muscles in a limb which is the site of an unhealthy suppurating wound, should suggest the oncome of tetanus, and indeed in some mild cases where the patient has been effectively protected by a prophylactic injection no other symptoms arise (localized tetanus).

In the **more acute cases,** however, general phenomena usually follow. The patient frequently complains first of a difficulty in opening the mouth, associated with a cramp-like pain in the muscles of mastication and of the neck. This soon becomes so marked that even a paper-knife cannot be inserted between the teeth (**trismus,** or **lock-jaw**), causing great difficulty in the administration of food; to it is added a fixed and rigid condition of the muscles of the back of the neck and of the face, the latter producing a curious grin-like appearance (**risus sardonicus**), whilst dysphagia is sometimes caused by spasm of the pharyngeal muscles. A considerable degree of fever is often present, but in some cases an apyrexial course is maintained until nearly the end. The spasms soon extend to the trunk and extremities, accompanied by cramp-like pains, and when fully established they may be excessively painful and violent, and the remissions between them but partial. The disease usually involves the respiratory muscles late in the attack. The more severe spasms can be excited by any form of stimulus, such as a bright light, the slamming of a door, a draught of cold air, or some voluntary movement, and are always of a tonic (*i.e.*, continuous) character. The body is contorted in various directions, and respiration may

be much impeded by the fixation of the thorax. Occasionally the body is arched backwards (**opisthotonos**) by the contraction of the muscles of the back, the recti abdominis being firm and tense—'as hard as boards'; sometimes it is doubled forwards (**emprosthotonos**), and in rare cases laterally (**pleurosthotonos**). The muscles may contract so violently as to be ruptured, whilst bones have been fractured, teeth have been broken, and the tongue has been almost bitten off. The intellectual faculties usually remain clear to the end, which is generally due to exhaustion from repetition of the convulsions, or more rarely to asphyxia induced by a prolonged fixation of the respiratory muscles. Before death the temperature sometimes runs up to 108°, or even, in one case, to 112° F., and it often continues to rise for a degree or two after death; such hyperpyrexia is due mainly to the continuous muscular contractions. The surface of the body is bathed in sweat, and the urine is scanty, and occasionally albuminous. Death may occur in twenty-four hours from the onset of the disease, or not for four or five days.

Chronic Tetanus usually shows a longer incubation period between the infection and the onset of the symptoms, which are less severe in degree, and the prognosis is better. The course is often afebrile, and the spasmodic contractions may be limited to the wounded part of the body whence the infection has arisen, or they may be general. Sometimes the patient lies in bed with his jaw partially fixed, and the muscles of his neck, back, and abdomen rigidly contracted, but with none of the characteristic convulsions.

A special and uncommon variety known as **cephalo-tetanus,** or **tetanus paralyticus,** follows injuries within the area of distribution of the cranial nerves, and especially those about the supra-orbital margin. It is characterized by the association of trismus with facial paralysis on the affected side, and for a time this may constitute the whole picture, so that the patient may walk to see the doctor; but later the usual tonic spasms occur in other parts of the body, and other cranial nerves may become affected, especially the third, leading to strabismus. Spasm of the muscles of deglutition and attacks of maniacal frenzy are sometimes present.

Diagnosis.—In the early stages tetanus must be distinguished from simple 'trismus' arising from dental irritation, from gastric and other forms of tetany, and from inflammatory ankylosis of the temporo-maxillary joint. This may be readily accomplished by noting that rigidity of the neck-muscles is also present in tetanus. Strychnine-poisoning leads to a very similar group of symptoms, but is recognized from tetanus by the contractions being more sudden and violent, the relaxation of the muscles between the spasms complete, so that the mouth can readily be opened, whilst the hands are involved in the contractions, a rare sign in tetanus, and the muscles of mastication often escape.

No difficu'ty should be experienced in distinguishing tetanus from hydrophobia, ow'ng to the very different nature of the convulsions in the latter case—*i.e.*, clonic and not tonic; moreover, they affect

the muscles of respiration and deglutition, whilst the history of the case, the early hallucinations, and the absence of tonic muscular contractions, are also characteristic features.

Laboratory methods may be unnecessary for the diagnosis of the disease when its definite symptoms have developed. In case of doubt films of some of the pus from the deeper portions of the wound should be examined for the presence of the 'drum-stick' bacilli, though too much importance must not be given to a negative finding. Moreover, *B. tetani* itself may sometimes not develop this characteristic appearance; and occasionally bacilli other than *B. tetani* may show similar terminal spore-formation. The result of such procedures should not be awaited before carrying out appropriate treatment of the wound and administering anti-tetanus serum. Anaërobic cultures should also be made in suitable media, *e.g.* in bullock's heart broth with a thick seal of supernatant liquid paraffin. The most certain test, however, is to take some of the deep discharge, dilute it with broth, and divide it into two parts; one of which is to be injected into a mouse or guinea-pig, whilst the other portion is mixed with 1 c.c. of tetanus antitoxin and then injected into another animal. If the former animal develops tetanic symptoms whilst the latter escapes, the diagnosis is assured.

The **Prognosis** is unfavourable in any case, but the longer the disease lasts, and the lower the temperature, the more likely is the patient to recover, whilst an acute onset, hyperpyrexia, sleeplessness, delirium, and strabismus are bad signs. The length of the incubation period is also a most important factor. Thus in 100 cases (*Lancet*, December 22, 1917) occurring in home military hospitals between December, 1916, and March, 1917, Sir David Bruce reported that the total mortality was 19·0 per cent.; in the cases developing within ten days of the wound 40 per cent. died; if within eleven to twenty-four days, 25 per cent. were fatal; but if the disease commenced after twenty-five days, the death-rate fell to 13·6 per cent. It is interesting to note that during the late war the death-rate from tetanus steadily fell from 57·7 per cent. in the first 231 cases occurring in 1914-15 to the above figure of 19·0 per cent.

Treatment.—In places where tetanus is known to be rife, it is advisable always to administer a **prophylactic** dose of antitetanic serum in cases of wounds or abrasions that might possibly be infected, especially if due to street accidents, etc. (see above, under ætiology), or if suspicious bacilli are found on microscopical examination of a scraping from the deeper parts of the wound. For routine prophylactic injection, the minimum dose should be 1,000 International =500 U.S.A. units,* repeated once or twice at seven-day intervals; but, and especially if there is much contamination of the wound, or much delay has occurred, it is preferable to give 3,000 International =1,500 U.S.A. units, or even more. In cases where it is proposed

* The Ministry of Health has adopted a unit which is one-half the strength of the well-known U.S.A. unit. Both standards are, therefore, usually stated on the label of most commercial anti-tetanus sera.

to attempt to clean out or excise the wound surgically, the serum should be injected intramuscularly some three or four hours previously.

The moment any actual symptoms of the disease have appeared, **no delay** in administering antitoxin in full doses should be permitted, and in this connection it is again wise to insist that the disease can often be recognized before trismus has occurred; at this stage a moderate dose of serum (10,000 International=5,000 U.S.A. units) will do more good than a huge dose at a later period. Treatment should commence with an intrathecal injection of 40,000 International=20,000 U.S.A. units or more, and, for this, concentrated serum (1,600 International=800 U.S.A. units per 1 c.c.) should always be employed. The amount of spinal fluid withdrawn should be a little less than the proposed dose, and the patient's head is lowered after the administration. An intramuscular injection of a similar amount should also be given. Should there be no improvement by twelve to eighteen hours, these doses should be repeated, and again every twenty-four hours for three or four days. Then, if necessary, 30,000, 25,000, or 20,000 International (15,000, 12,500, or 10,000 U.S.A.) units may be given daily intramuscularly. Until all danger of relapse appears past, smaller doses may be administered subcutaneously every few days. Intravenous administration is undesirable, as the risk of anaphylactic symptoms is greater.

The **treatment of the wound** is of great importance, for, of course, the serum treatment deals only with the toxic bodies absorbed from it, and has no influence upon the local infective processes. Much will depend upon the position and extent of the wound or wounds, and, where these are multiple, upon whether the infection with the tetanus bacilli has occurred in one only or in several. The surgeon must consider whether thorough excision of the wound is feasible; or whether, when the infection has occurred in a limb, amputation well above its site, as removing completely the source of the toxin, is inevitable; or whether he may safely rely upon the local application of oxidizing antiseptics and satisfactory drainage. It is certain that any injudicious manipulation of the wound may do more harm than good by distributing toxin, and therefore one's choice must be between an amputation well above and conservative measures. The former has certainly proved very successful in suitable cases, and when the causative wound is deep, involving muscles and bones, badly infected and difficult to sterilize, amputation is often the method of choice. In the less serious cases after a prophylactic dose of serum the wound should be opened up thoroughly and yet with the greatest possible gentleness, cleansed with oxidizing antiseptics, and dressed with hypertonic salt solution or treated by Carrel's method. The appearance of healthy granulations will probably synchronize with an amelioration of the symptoms.

As to **symptomatic treatment**, the chief essential is to keep the patient quiet in a darkened room and free from all sources of irrita-

tion which would determine reflex spasm of muscles. Opium, chloral hydrate, bromide of potassium, chloretone, and other sedatives are of value in reducing reflex excitability and calming the nervous system, and must be given in full doses. Food should be nutritious, fluid, and unstimulating; it has been suggested that the patient should be fed twice a day by a stomach-pump under chloroform, or by a soft rubber catheter through the nose, but rectal feeding may in suitable cases be tolerated, and, indeed, the patient must be given an abundance of normal saline solution by this route in order to help in the elimination of toxins and to relieve his thirst.

The spasms can be diminished or almost abolished by the intrathecal or subcutaneous injection of a sterilized solution of sulphate of magnesia, which paralyzes the motor cells; 2-4 c.c. of a 25 per cent. solution may be given by lumbar puncture, or 10-20 c.c. of a 10 per cent. subcutaneously every four hours. It has no effect on the toxin, and in the milder cases, if the spinal theca is to be punctured, it seems wiser to introduce antitoxin than an agent the curative value of which is very doubtful. If, however, the case is a grave one and the patient is becoming rapidly exhausted by the multiplicity and severity of the tetanic convulsions, it may be wise to inject the magnesium sulphate in order to give the patient some rest and permit the antitoxin time to act. The medical attendant must, however, be prepared, if necessary, to perform artificial respiration for as long as may be required, for the respiratory muscles do not escape the generalized paralyzing effect of the drug.

Hydrophobia or Rabies.

Hydrophobia or rabies is an acute general infective disease, transmitted from animals, especially rabid dogs, wolves, and cats, to other animals or to man It consists in an affection of the central nervous system, and one of its most marked features is the long and variable incubation period. It never originates 'idiopathically' either in animals or man, infection usually following a bite; but experimentally it can be transmitted through unbroken mucous membrane, *e g.* of the nose. It has also been proved that if an affected animal merely licks an abraded surface the disease may be transmitted, even when the animal has not at the time shown any of the more typical signs of rabies.

In the **Dog,** rabies manifests itself three to five weeks after infection, but the period varies considerably; the original wound usually heals perfectly, or there may be some inflammatory thickening about it. The disease commences by a complete change of character, which is manifested possibly by snappishness and irritability, especially towards other animals, by restlessness, or by the dog moping in dark corners, with a depraved appetite, eating any kind of rubbish or dirt, and even its own excreta, or standing aimlessly in the hot sun. This period lasts for two or three days, and is perhaps the most dangerous, since there is nothing very suggestive about the symptoms. It is usually followed by a stage of violence or frenzy, when the animal runs 'amok' and bites anything and everything that comes in its way. The final stage is one of paralysis, going on to death, during which the mouth is filled with ropy saliva, which the animal vainly tries to scratch away; the bark loses its ring and becomes hoarse, and as the disease progresses the lower jaw becomes paralyzed; finally, after partial or general convulsions, the animal dies five or six days from the onset of the symptoms.

In **Man**, the incubation period varies somewhat, but is usually not longer than six or eight weeks; in Egypt the average day for the onset of symptoms

is the nineteenth.* During the interval the wound may heal, although the scar remains tender and neuralgic. The symptoms commence by fever, followed by a vague sense of terror, with illusions of the senses and disturbance of the mind; insomnia is marked. In about three days the more characteristic signs appear. The terror persists and becomes more evident, and spasmodic attacks develop in connection with the muscles of respiration and deglutition, which become more marked if water is brought near the patient, or if he attempts to swallow. The attack is really a spasm of the muscles of the throat and of the diaphragm, comparable to ' the long shuddering inspiratory clonic spasm that takes place when a child is immersed in cold water,' with fixation of all the accessory muscles of respiration in the neck, so that the chest is raised and fixed. The sound produced by this spasm of the diaphragm is of a loud hiccoughing character, and does not much resemble the barking of a dog to which it has been likened. Towards the termination of the disease the spasms become more and more terrible, and the patient's mental state is most distressing, he is in a condition of abject terror, always seeking to keep in the light, possibly striving to get out of windows, probably tearing off all his clothes, and constantly chattering. This violent period lasts a day or two, and is followed by the terminal stage of paralysis of the lower limbs; but unhappily his consciousness and terror persist, and he dies huddled up, perhaps, in a corner of a room from exhaustion. The disease lasts about a week, but may be fatal in two days In rare cases the symptoms may be paralytic from their start.

The **Post-mortem Changes** are mainly negative. The nerve-cells of the medulla, cord, and elsewhere may be found degenerated. The salivary glands are always somewhat enlarged. The disease may be diagnosed in a suspected dog by the recognition of the Negri bodies in the nerve-cells, *e g.* of the hippocampus major, and for descriptions of these and theories as to their nature, special books should be consulted. They are also found in most human cases of the disease.

Preventive Measures should be adopted *immediately* in all cases of bites from dogs which are either rabid or may possibly be in the incubation-stage of the disease. The circulation in the limb should be arrested by a string or bandage, bleeding encouraged, and, if free excision of the part is not feasible, the actual cautery or some powerful caustic, *e.g.* fuming nitric or pure carbolic acid, applied. Even if such application is not made in time to prevent the occurrence of the disease, the onset of the symptoms may be thereby delayed and time gained for the prophylactic treatment by the original Pasteur method, or one of its more recent modifications. Such treatment can be administered only at a fully equipped Pasteur Institute, to which the patient should be sent without delay. Treatment with antirabic serum and more recently with various types of vaccine (*e.g.*, carbolized ' fixed virus ' or ' etherized ' vaccine) has also been carried out, apparently with marked success, in some of the Pasteur Institutes. In cases where such prophylactic treatment has not been carried out, and in which active symptoms have appeared, only **palliative treatment** can be adopted Every source of irritation and disturbance must be removed, and the patient kept absolutely quiet. Local applications to the pharynx are useless, and for adults the only drug of value is hyoscine combined with morphia. In children chloral and sulphonal are of value Nourishment should be administered for choice by the rectum.

Anthrax.

This disease results from infection with *Bacillus anthracis*, which produces in sheep, cattle, and other animals the so-called ' splenic fever,' characterized by well-marked fever and enlargement of the spleen. In man, if the organism is inoculated through the skin, it produces a local inflammatory lesion, known as ' malignant pustule,' or a more diffuse condition termed ' anthrax œdema ', sometimes the latter follows the former. If the virus is absorbed by the lungs, it originates a general inflammatory disorder, known as ' woolsorter's disease.' An intestinal form of infection also occasionally occurs.

* Dolbey, ' Hydrophobia in Egypt,' *Lancet*, March 15, 1924.

B. anthracis (Plate IV., Figs. 1 and 2) is one of the largest of the pathogenic bacteria. It is found in the blood of diseased animals in the form of bacilli single or in chains. It is aerobic, immobile, grows best at about blood-heat, and liquefies gelatin. Well-marked spores are formed within the bacillus when cultivated artificially at a suitable temperature and in the presence of oxygen; but spore-formation has not been observed in the living tissues. The bacilli alone are readily killed by boiling for a few seconds, whilst the decomposition of the carcase in which they are present causes their death in about a week or less. The spores, however, are very resistant; for, whilst a 1 per cent. solution of carbolic acid kills the bacilli in two minutes, the spores remain alive after a week's immersion. Moreover, alcohol and even a 5 per cent. solution of carbolic acid have no lethal effect on them, unless acting for a long time. If a mouse is inoculated, say, at the root of the tail, with a needle, the point of which has been dipped in the blood of an animal which died of splenic fever, it succumbs in less than twenty-four hours, and bacilli are found in nearly every organ of the body

Some animals are immune against the attacks of anthrax, especially the dog and the white rat; and one of Pasteur's most useful discoveries was that of providing artificial immunity for cattle and sheep, which are highly susceptible to the infection, by inoculating them with an attenuated virus, obtained by growing the bacillus for some time at 42° C., at which temperature it is also rendered asporogenous.

Incidence.—Infection with this organism usually occurs chiefly amongst farmers and others who tend the living animal, or butchers who deal with the carcase; it is also met with amongst workers who handle hides, wool, or hair. The infection has in some cases been traced to the use of shaving brushes made from bristles contaminated with anthrax spores.

Malignant Pustule (Plate II., Fig. 1) is seen usually on the face or forearm, or, in the case of meat- or hide-porters, about the neck or shoulder. It commences as an angry red pimple at the site of inoculation, and rapidly spreads, with much infiltration of the base, whilst the centre becomes covered with vesicles, the serum within being blood-stained or dark brown in colour, and containing the typical bacilli. This stage is associated with no pain, but only with great itching and irritation. As the pustule develops, the centre gradually darkens to a brownish-black slough, around which is a ring of vesicles, with, beneath and around it, an area of brawny congestion and œdema. Neighbouring lymphatic glands also become enlarged. Generally, there is a certain amount of fever and malaise, which is not pronounced until about the fourth or fifth day. The temperature then rises to 102° or 103° F., the pulse becomes rapid and irregular, and gastric irritability, vomiting, and flatulence more marked. Should the disease progress unchecked, the surrounding parts are involved in a rapidly spreading œdema; thus from the face it may extend to the neck, chest, and back. The respirations become shallow and embarrassed, whilst signs of grave constitutional disturbance, such as delirium or coma, manifest themselves, and the patient may succumb, generally in less than a week, sometimes in thirty to forty hours More commonly the case runs a less unfavourable course, limiting itself to the local manifestations, which gradually clear up, the slough separating and the œdema disappearing.

Anthrax Œdema, though usually occurring in association with malignant pustule, may occasionally develop without the formation of such superficial lesion. It tends to run a rapidly fatal course, and is usually seen about the face, the skin becoming red and brawny, as in erysipelas, and after a time covered with vesicles, whilst finally gangrenous patches appear. The lymphatic trunks and glands are also involved.

The condition may be mistaken in the localized form for accidental vaccination or for a staphylococcal infection, but is recognized by the presence of the bacilli in the serum of the vesicles; in cases of doubt cultures and animal inoculations should be made.

Woolsorter's Disease is the term applied to the condition in which the virus gains access to the system by the inhalation of the dried spores. The primary

lesion is usually in the mucous membrane of the lower part of the trachea and of the larger bronchi, from which it rapidly spreads to the lung, mediastinum, and pleura. The patient complains of fever and malaise for a few days, and the disease runs a rapid course, with high fever, great dyspnœa, impairment of the circulation, and finally collapse in a great majority of the cases. A much rarer form of the disease is the alimentary type, when the organisms are swallowed. In the stomach, the unspored anthrax bacilli are usually destroyed by the acid chyme; but should any of them or their spores reach the intestine, the alkaline contents form a suitable breeding-ground, and the walls of the gut are soon attacked and the disease becomes general. Colic, cramps, vomiting, and blood-stained diarrhœa are the most marked features in such a case. The intestinal type appears to be not quite so virulent or fatal as the pulmonary, but is decidedly worse than the cutaneous.

Treatment.—In the cutaneous affection, excision of the necrotic patch and of all the infiltrated tissues around, and the application of the actual cautery or of pure carbolic acid, were formerly recommended, though those who have had much experience think such treatment of little value, and put their trust in carbolic fomentations or mercurial ointment.

Several sera (p 26) have been introduced for the treatment of anthrax, and good results have been obtained, especially in the localized forms of the disease. Sclavo's serum (obtained by immunizing asses or goats) has been most used, the dose being 50 c.c., preferably injected intravenously, and repeated in twenty-four hours, if necessary Sobenheim's serum, combined with vaccine-treatment, has also given good results. The use of either serum may be followed by fever and sweating, and improvement is often very rapid.

Gonorrhœa.

Gonorrhœa is an infective process due to the action of a specific micro-organism, the *Gonococcus* or *Neisseria gonorrhœæ* (Plate I., Figs. 5 and 6), and characterized (in its commonest form) by a discharge of pus from the urethra. The organism is a Gram-negative diplococcus, this fact being of great importance in diagnosis, since most of the diplococci with which it might be confounded retain the stain. Each coccus of the pair is usually kidney- or bean-shaped, the two lying with their concave surfaces facing one another. It may occur in large numbers in the pus from a gonorrhœal lesion, and in most cases it is found within the polymorphonuclear leucocytes. This is very characteristic, as also the fact that, whilst most of the cells are usually free from organisms, those that are invaded by cocci contain them in abundance (see Plate I., Figs. 5 and 6, in which some of the cells are free from germs, but in others the diplococci can be seen clustered round the polymorphous nuclei). The pus also contains desquamated epithelial cells, in or on which many cocci may often be seen, and varying numbers of the latter may also be found free.

Diagnosis.—For the detailed description of the methods of laboratory diagnosis of gonorrhœa, both microscopical and cultural, textbooks of practical bacteriology should be consulted. In the **male,** especially in its more acute stages, the diagnosis can often be made at once by the examination of stained films of the discharge. At least three films should be made to be stained by Gram's, by Leishman's, and possibly by other methods. When the discharge is abundant, this is usually a simple matter; but if it is scanty, especially in certain chronic cases, such smears can best be made

from the morning discharge before the patient has passed water; and it may be necessary to 'milk' the penis for this purpose. When the infection has passed its acute stage and may have reached the posterior urethra, prostate and seminal vesicles, massage *per rectum* should be performed, any discharge appearing at the meatus being collected in a suitable sterile vessel, and also specimens of urine obtained both before and after this procedure. If cultures are to be made, for diagnosis or for the preparation of an autogenous vaccine, it is essential that this should be done immediately, on appropriate special media, *e.g.* blood-agar, preferably previously warmed to body-temperature. For a satisfactory diagnosis **in the female,** such cultural methods are often necessary, the material for these and also for microscopical examination being obtained by expressing some of the muco-purulent discharge from the urethra, and also by taking a swab from the cervical canal through a sterile speculum, after the contaminating surface discharge has in both instances been thoroughly wiped off with surgical swabs. It must be particularly emphasized that, except in the vulvo-vaginitis of young children, it is practically always useless and even misleading to submit for examination for the gonococcus films or swabs of the general leucorrhœal vaginal and vulvar discharge, which contains enormous numbers of mixed organisms, some of them not infrequently morphologically resembling the gonococcus, which itself may be present in this general discharge only in such minimal numbers as to escape detection. The **complement-fixation test** (p. 21) is now extensively used as an aid to the diagnosis of gonococcal infections. In suspected cases in either sex, where examination by the above methods has failed to reveal the presence of the *Gonococcus,* a positive reaction is usually obtained if the infection has spread beyond the anterior urethra, and persists for one or two months after cure. In the female, weaker reactions are obtained than in the male. In either sex a positive reaction is diagnostic of the presence or very recent existence of gonococcal infection, but a negative reaction, especially in the female, does not invariably mean freedom from infection. It must be remembered, however, that the administration of a gonococcal vaccine also produces a positive reaction with this test.

(I.) **Gonorrhœa in the Male.**—The primary lesion is an acute catarrhal inflammation of the anterior portion of the urethra, which quickly runs on to suppuration, and is likely to spread back to the deeper portions of the urethra, the prostate, bladder, seminal vesicles, or epididymis. Important alike in prognosis and treatment is the fact that the gonococcus is found, not merely on the surface and in the mucous membrane of the urethra, but also deeply in the submucous coat and in the mucous glands and glandular lacunæ. The infection may remain limited to the genito-urinary system, but secondary infection by way of the blood-stream may take place, especially of joints (gonorrhœal rheumatism); and, in very rare cases, ulcerative endocarditis or even meningitis has supervened.

The Symptoms of Acute Gonorrhœal Urethritis commence usually in from two to eight days after infection. Most commonly the discharge appears about the third or fourth day, being preceded by itching of the meatus and a scalding pain on passing urine. The lips of the meatus are congested and swollen, and the discharge, which is at first thin and mucoid, soon becomes thick, abundant, and yellow in colour. This stage lasts for a variable time, and is sometimes associated with a good deal of dragging pain in the back and loins, together with some constitutional disturbance and fever. The bowels are usually constipated, and the appetite impaired. Hæmorrhage from the urethra may result from the congestive swelling of the mucous membrane, which, together with the pain on micturition, may also lead to retention of urine.

If the condition is neglected, but often in spite of treatment, the inflammation spreads backwards, giving rise to what is termed a **Posterior Urethritis.** It generally becomes evident about the end of the second week, and is characterized by frequent and painful micturition, a sense of pain and heaviness in the perineum, possibly a little blood in the urine, and a general feeling of depression. This extension backwards is always serious, since it is liable to be followed by complications involving the prostate, testis, or seminal vesicles, whilst it is an extremely common cause of **Chronic Gonorrhœa** or **Gleet,** in which a more or less abundant discharge continues for some time without any troublesome symptom other than occasional scalding on passing urine. A gleety discharge is often thin and muco-purulent, and may be so slight as merely to cause the lips of the meatus to stick together, or may be evident only on squeezing the urethra after a night's rest. This may last for a long time, perhaps years, and it must be remembered that even in this stage the disease can still be transmitted to women. Gleet is sometimes due to invasion of deep lacunæ, or to an ulcerated or granular condition of some portion of the mucous membrane; the discharge is then yellow, and the urethra is tender on the passage of a sound; the presence of the local focus can be recognized by the urethroscope. In most cases gleet arises from chronic prostatitis, a condition not uncommonly associated with chronic infection of the vesiculæ seminales. The latter condition may be recognized on rectal examination, whilst, when the prostate is involved, flocculi of mucus in the shape of worm-like threads may be detected in the urine, especially after massage of the gland by the finger introduced into the rectum.

When the disease has lasted for a considerable time, or after repeated attacks, a certain amount of peri-urethral infiltration is certain to follow, and a stricture of the urethra may result; this may also be due to the cicatrization of the ulcerated and granular patches in the urethral wall, alluded to above.

The source of a chronic urethral discharge is by no means easy to ascertain. Examination of the urine by the two-glass test, which was formerly relied on, is in reality quite useless, inasmuch as all the discharge accumulated in the urethra is washed out into the first.

If, however, the urethra is cleansed by passing a portion of the urine into a glass, and then thorough prostatic massage is carried out, the examination of the first urine passed afterwards will be of great significance; if it contains pus and gonococci, then infection of the posterior urethra is assured. Examination by the urethroscope or endoscope is, however, much more reliable and useful. The instrument consists of a metal tube fitted with electric illumination in such a way as to render visible the walls of the urethra, which should be distended with air by a bellows. A commencing stricture can be easily recognized, as also ulcerated areas, patches of granulations more or less polypoid, etc.; and the use of this instrument enables suitable local treatment to be undertaken.

Every purulent discharge is not necessarily gonorrhœal, since a simple urethritis may follow connection with a woman who is suffering merely from a non-gonococcal form of leucorrhœa. In these cases infection may be due to ordinary pyogenic cocci, or possibly to *B. coli communis*. Although the history may suggest a simple urethritis, the diagnosis can be made only by the microscopical examination of the discharge. It must be remembered, however, that gonococci are capable of remaining in a latent or passive state for a very long time in the folds or crypts of a mucous membrane, and hence a person who has once suffered from it may be capable of transmitting the disease, although no obvious evidence of its existence is present. Moreover, in a gouty patient, a highly acid condition of the urine, especially if it is loaded with uric acid crystals, may light up into activity a urethritis which has been quiescent for some time.

The practitioner is not infrequently consulted as to the advisability or otherwise of marriage after an attack of gonorrhœa; the mere cessation of the discharge is not sufficient to warrant such a step. The only reliable test is to light up a fresh attack of urethritis by the injection of some chemical irritant—*e.g.*, a solution of nitrate of silver (1 in 100)—and to examine the discharge bacteriologically for the presence of gonococci.

Prophylaxis.—Whilst it is obvious that the only effective means of avoiding infection with a disease so easily contracted as gonorrhœa is the abstinence from exposure, and that for this purpose moral restraints must be relied on, yet whilst human nature remains more or less constant in type such abstinence is unlikely to be general, and venereal disease will persist, with all its crippling and mutilating results, which are only too liable to spread to innocent victims. From the point of view of the State, to protect these, and also the exposed individual, by the adoption of simple precautionary measures, is necessary. The fact that the virus is mainly external immediately after exposure, and only penetrates to the deeper parts after an appreciable interval, is the key to prophylactic treatment, which consists in the effective washing of the parts with soap and water, and bathing them subsequently with a 1 in 2,000 solution of potassium permanganate. The greatest care should be taken of the frænum and meatus, the lips of which should be opened so as to allow some

of the solution to enter. The use of calomel ointment to smear over the parts has also been advised, but it is obviously a weak antiseptic, and the method advised above has been proved to be quite efficient in the majority of cases.

Treatment.—It is essential that students and practitioners should avail themselves of the opportunities of studying the modern methods of treatment of gonorrhœa provided in the venereal clinics set up by the local health authorities, and often working in connection with the more important hospitals. There are two great desiderata to be kept in mind in such treatment—*viz.*, the provision of effective drainage for the discharge, and the building up of the powers of the fluids and tissues of the body to combat the organisms.

Drainage is provided by washing out under pressure the whole lower urinary tract, including the bladder as well as the urethra, with a weak solution of potassium permanganate (1 in 5,000 to commence with, but increasing the strength as the infection becomes more chronic or approaches a cure, when a 1 in 2,000 solution may be used). The apparatus required is a receiver to hold about 2 pints, connected by a rubber tube with a glass cannula protected to prevent splashing backwards, although a simple blunt-ended cannula quite well suffices. The lotion is placed in the receiver at a temperature of 104° F., and provision is made for the escape of the injected fluid after use into a suitable vessel or trough. The patient is first instructed to micturate so as to wash away all discharge lying in the urethra. At first the receiver is kept only about two feet above the patient's pelvis, so as not to force open the compressor muscle and carry the fluid into the posterior urethra; the anterior portion is alone washed out two or three times a day, but the force employed is sufficient to dilate the tube and open up the crypts and lacunæ so as to bathe them effectively with the antiseptic lotion. After a day or two the patient is encouraged to fill his bladder with the lotion; this is best accomplished by raising the receiver to a height of about three feet above the pelvis and instructing him to breathe easily and to attempt to micturate whilst the fluid is being injected; the compressor will thus become relaxed, and the fluid enter the bladder. After a little practice the patient will be able to distend his bladder in this manner, and thus even if a few germs are carried back they are floating in a large bath of antiseptic lotion in which they are harmless. All the crypts and recesses of the urethra, both superficial and deep, are by this means opened up and brought into contact with an abundance of antiseptic fluid, which is expelled after being retained for twenty or thirty seconds. The effect of this treatment is most satisfactory, the discharge rapidly diminishing, but it must be persisted in until all discharge has ceased.

At the end of ten days or a fortnight, massage of the prostate and vesiculæ is added so as to expel infective material from these parts, in which they are only too liable to lodge, and the injection is again repeated. The whole course of treatment lasts on an average for about five weeks, and then the man may usually be regarded as free,

but necessarily the prognosis depends on the period when he came under treatment.

General Treatment.—The constitutional reaction is sometimes severe, the burning and smarting great, and the patient has great difficulty in micturition. Under such circumstances it may be wise to keep him in bed for a few days on a fluid non-stimulating diet which excludes meat, alcohol, tea, and coffee; he is permitted to drink barley-water, and milk and soda water; alkalies and purgatives are administered, with tincture of hyoscyamus as a sedative, and all local interference is avoided. A hot bath will usually overcome the difficulty in micturition; every effort must be made to avoid the necessity of the introduction of a catheter. At the end of a few days the symptoms may have subsided sufficiently to warrant the commencement of local treatment by injections, and then the patient may be allowed to take quiet exercise or to go about his ordinary duties; but the local treatment must be effectively and regularly carried out, and the scrotum should be supported in a suspender.

Only *when the above treatment is absolutely impossible* should the old-fashioned plan of giving small injections introduced into the urethra by glass syringes be adopted. For this purpose the organic silver salts are probably the most useful—*e.g.*, protargol ($\frac{1}{2}$-2 per cent) or argyrol (1 per cent), though an injection of zinc sulphate, gr. 2, tincture of catechu, ♏10, tinct. opii, ♏5, to an ounce of water is of considerable value; permanganate of zinc (gr. $\frac{1}{4}$ to 1 oz.) is also effective A small syringe holding about half an ounce is used, and the injection is warmed. After micturition the nozzle is introduced into the meatus, and the fluid gently injected up the canal; by closing the lips of the meatus the fluid can be retained for about half a minute and is then allowed to run out. This must be repeated four or five times a day, and in the interval a gonorrhœal bag is worn to soak up the discharge that escapes. Treatment of this type must be continued until all discharge has ceased, but unfortunately the acute process often becomes chronic, and a gleet results At the same time oleo-balsams in the form of oil of sandal-wood (♏10 in capsules three times a day), copaiba (♏10 in capsules or mixture thrice daily), or cubebs ($\frac{1}{2}$ to 1 drachm doses, wrapped in wafer paper), may be administered, but these are all liable to cause indigestion, and certainly copaiba and cubebs may lead to a bright red erythematous rash which causes much irritation and may be extensively diffused over the body. It is more than doubtful whether these drugs are of any real value.

The treatment of **Gleet** is often a matter of difficulty, but as more efficacious methods for dealing with the acute stage are enforced, gleet should become an almost unknown condition. The first principle of treatment consists in finding out the actual nature and site of the lesion, and to this end the urethroscope is used. If patches of granular urethritis are present or localized ulcers, topical applications of nitrate of silver in strengths up to 5 per cent. should be made. In the absence of these lesions the gonococci are probably to be found in the lacunæ of the urethra, the crypts of the prostate, or the seminal vesicles. These must be emptied methodically by dilatation of the urethra with Kollmann's dilator (Fig. 32) or some such appliance, or by massage of the prostate or seminal vesicles two or three times a week; the discharge thus expressed is washed away, and the urethral canal cleansed by intravesical injections of permanganate of potash.

Sometimes injections of silver salts into the urethra so as to reach the posterior portion are desirable; the simplest method is to pass a measured length of rubber catheter (about 7½ inches) into the urethra and then inject the fluid. A drachm or two of a 1 in 1,000 solution of silver nitrate will suffice twice or thrice a week. During such treatment the general habits of the patient must be regularized. The diet should be simple and non-stimulating; alcohol, tea, and coffee should be avoided; undue exercise, especially after the massage and injections, forbidden; and absolute sexual continence enjoined, so as to prevent the spread of the infection. Marriage necessarily is prohibited until the condition is completely cured.

Treatment directed towards an increase in the powers of the body fluids or tissues to deal with the gonococci is sought in two chief directions.

(1) **Vaccine-Treatment of Gonorrhœa** has proved to be of considerable value, especially in the subacute stage when the discharge is slacking off. It is often of great assistance in the treatment of gleet, as also in many of the complications, *e.g.* of the joints

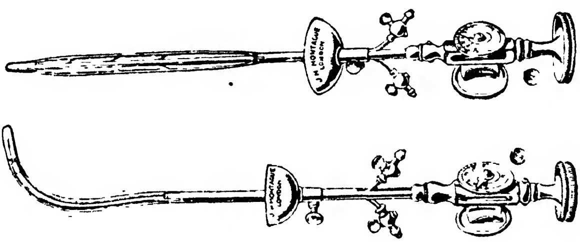


FIG. 32.—KOLLMANN'S URETHRAL DILATORS, AS EMPLOYED FOR THE ANTERIOR AND POSTERIOR PORTIONS OF THE URETHRA RESPECTIVELY.

and fibrous tissues. The vaccine is prepared as described on p. 23, and the usual initial dose is 5 million. It appears that some strains of cocci are of greater value than others in assisting immunity, and therefore a stock vaccine, if used, must be polyvalent—but an autogenous vaccine is always preferable. Furthermore, the infection usually becomes a mixed one, such organisms as *Staphylococcus albus*, streptococci (*e.g.*, *S. fæcalis*), diphtheroid bacilli, etc., and sometimes *B. coli*, being often present along with the gonococci, and, especially in many old-standing cases, eventually even coming to replace these. These organisms should therefore also be included in the vaccine.

(2) **Diathermy** is now much used in treating some of the results of gonorrhœa. Special textbooks must be consulted for descriptions of the exact technique, and for the various hypotheses as to its method of action upon the organisms and tissues. The chief conditions for which such treatment is advised are subacute or chronic urethritis, prostatitis, and vesiculitis; inflammation of the epididymis and

testis usually rapidly subside; and infection of the cervix and urethra in women is also often cured; gonorrhœal arthritis is almost always benefited. It is at present not yet possible to define very exactly the extent to which this treatment can be applied, but there is no question that in diathermy we have at our disposal an agent of considerable efficacy in the treatment of gonorrhœa or its results.

Complications due to Direct Extension.—**Balanitis,** apart from gonorrhœa, is of frequent occurrence in patients with long foreskins, and is then ordinarily due to pyogenic organisms. It often, however, supervenes in gonorrhœa, and, as a secondary result, inflammation of the lymphatics of the penis and inguinal bubo may follow. Sometimes this inflammation results in the development of red papillomatous outgrowths, known as **gonorrhœal warts,** which are found mainly on the glans penis, but occasionally on the preputial margin (Chapter XLIV.).

Lacunar Abscess arises from infection of one or more of the glandular lacunæ with the gonococcus or accompanying pyogenic organisms. A tense painful swelling forms along the floor of the urethra, which may project into the passage and discharge either into the urethra, or externally, or both; in the latter case a **penile fistula** will result. The abscess should be opened as early as possible from without, so as to prevent the latter occurrence, which is often very difficult to treat. If a fistula forms within a short distance of the meatus—a common situation—it seldom heals of itself, but may in some cases be closed by an application of the electric cautery or a weak solution of nitrate of silver. If, however, it remains intractable, the fistula should be laid open into the meatus. When it occurs in the body of the penis, a plastic operation is usually required; it consists in paring the edges and dissecting up the skin on either side so as to bring it together in the median line.

Chordee, or painful erection, results from inflammatory infiltration of the corpus spongiosum or one of the corpora cavernosa, so that the penis, when erect, is bent downwards or to one side. It is exceedingly painful, and most marked at night when the patient becomes warm in bed. It is best prevented by the use of bromide of potassium or other sedative at bedtime, and when present may be treated by cold applications.

Inflammation of Cowper's Glands may in some cases give rise to deep suppuration in the perineum, and unless treated early by incision may lead to a urinary fistula.

Inflammatory conditions involving the prostate, seminal vesicles, epididymis, and bladder, caused by gonorrhœa, are discussed elsewhere.

(II.) **Gonorrhœa in the Female.**—Gonorrhœa may frequently be an unsuspected source of uterine and pelvic trouble. Apart from sexual intercourse, the disease may also be contracted from the use of infected towels, garments, etc., and even from the infected seat

of a water-closet. The primary lesion is usually either in the **urethra** or in the **cervical endometrium,** or in both. **Vulvitis** is by no means uncommon, but in the adult a gonorrhœal vaginitis is unusual. Sometimes discharges from the cervix accumulate in the vagina and undergo septic changes, producing a simple vaginitis by the direct action of the bacterial toxins, but the gonococci do not readily attack the vaginal mucosa, and for this reason the presence of gonorrhœal infection in the female is often overlooked. In children a true **vulvo-vaginitis** occurs sometimes in epidemic form, *e.g.* in girls' schools and other institutions.

Symptoms and Complications.—The symptoms in acute cases are those of heat and burning about the genitals, combined with a purulent discharge and painful micturition. The **urethra** can be seen and felt to be swollen, and its orifice is red and congested; and pus can be expressed from it. If the **cervix** is involved, the uterus becomes congested and painful; severe backache is noticed, and perhaps some tenderness on hypogastric pressure, with a blood-stained discharge. In the more chronic cases nothing may be noted except that the periods are painful, and that there is a certain amount of leucorrhœa, with occasional attacks of discomfort and frequency in micturition.

In all cases the inflammation is likely to spread, either to the bladder, or up the uterus to the Fallopian tubes (**salpingitis**), ovaries, the cellular tissue of the broad ligaments, etc., or to the peritoneum —in which case the inflammation may be localized, producing adhesions around the fimbriated extremities of the tubes, and these are often an important cause of sterility. Occasionally a more generalized peritonitis results (*q.v.*).

Treatment follows along the same lines as in the male—*viz.*, by bathing the parts frequently with an abundant supply of weak permanganate of potash (1 in 2,000). The patient lies on her back in the lithotomy position, and the vagina is filled with the lotion from a douche can, the fluid being retained for a time. It may be desirable to apply tincture of iodine or a solution of nitrate of silver to the cervix through a speculum, or to the urethra. In addition, treatment by diathermy and vaccine, preferably autogenous, should be employed when possible.

Complications arising from Direct Transmission of the Virus.—**Gonorrhœal Proctitis** sometimes results in the female from infection of the anal region, etc., by the discharge which escapes from the vulva, whilst in both sexes it may be due to unnatural practices. It is characterized by tenesmus and a thick muco-purulent discharge, and is treated by injecting lotions of acetate of lead and opium, or of boric acid.

Gonorrhœal Rhinitis has also been seen in a few cases. It leads to an abundant discharge of pus, and should be treated by warm soothing injections, followed after a time by dilute astringents.

Gonorrhœal Conjunctivitis (see Chapter XXXVII.).

Complications resulting from General Absorption.—Gonorrhœal Affections of Joints are not uncommon sequelæ, arising usually in the subacute stage of the disease. For clinical features and treatment, see Chapter XXIII.

Gonorrhœal Fibrositis.—Any muscular, tendinous, ligamentous, or aponeurotic tissues may become inflamed and painful during the course of an attack of gonorrhœa. In the case of involvement of the ligaments supporting the arch of the foot, the patient must not be allowed to walk, otherwise the arch may give way and a permanent flat-foot result.

Gonorrhœal Sclerotitis, or inflammation of the deep subconjunctival fibrous tissue, is a rare affection, arising quite independently of gonorrhœal conjunctivitis. It is characterized by marked subconjunctival redness, the globe of the eye becoming distinctly tender. Local applications of atropine are required and, if need be, leeches to the temples.

The pathology of the complications described in the last two paragraphs is uncertain. They are probably due to the presence in the tissues of a small number of gonococci of enfeebled virulence.

Gonorrhœal Endocarditis, Etc.—Occasionally the cardiac valves become infected and inflamed, and an ulcerative endocarditis due to gonococci has been observed. More rarely a true septicæmic invasion may occur from a generalized development of gonococci in the blood.

Gonorrhœal pyæmia, a condition of great rarity, is characterized by a formation of secondary abscesses in various parts of the body, containing only the gonococcus. Gonorrhœal meningitis is another extremely rare complication of the disease.

Soft Chancre (*Ulcus Molle*).

Soft Chancre is a local infective venereal lesion, which is rarely seen elsewhere than on the genital organs. It is due to a specific bacillus, which was first described by Ducrey, and which occurs in the form of short chains consisting of slender rods, which are Gram-negative and do not form spores. The organism can be cultivated, though with difficulty, and in the lesion ordinary pyogenic organisms are often also found. Infection is followed by a typical series of events. A red papule appears in a few hours, and in two or three days a vesicle, surrounded by a zone of angry hyperæmia, is seen. The serum within the vesicle soon becomes turbid, and by the fourth or fifth day a fully-developed pustule is present; as soon as the cuticle is lost, an ulcer forms with cleanly-cut edges and a sharp, distinct outline. The chancre gradually increases in size up to perhaps half an inch or a little more, and then if kept clean heals in about three weeks. Such sores may be met with on any part of the penis, but more especially on the prepuce and glans, or on the corona glandis, and in the case of the female about the vulva. It sometimes occurs within the meatus, producing a considerable discharge which may

simulate that of gonorrhœa. The lesion is usually very painful and tender. The secretion is highly infective, and if inoculated elsewhere on the patient produces a typical sore, showing that the condition is purely local, and that no constitutional immunity results from its presence. The discharge from a true syphilitic chancre may produce a localized pustule on auto-inoculation, but no typical primary sore. Frequently several soft sores are present at the same time, and the discharge from one chancre is very likely to produce a similar affection (' satellite ' chancre) on any cutaneous or mucous surface brought into contact with it; *e.g.* it may spread from prepuce to glans, or *vice versa*, or from one lip of the vulva to the other. It is a curious but well-authenticated fact that soft chancres are rarely seen on any part of the body other than the genital organs.

Complications of the typical soft chancre may occur. Thus, if a long foreskin is present, the discharge may be retained beneath it, and extensive ulceration follow, which may even result in the glans protruding through the upper part of the prepuce, which drops beneath it. If the frænum is involved, hæmorrhage may supervene from ulceration into a branch of the artery found in that structure. When there is much inflammation, the base of the sore becomes indurated and infiltrated, somewhat resembling the Hunterian syphilitic hard chancre. Not infrequently a co-existing syphilitic infection may complicate the diagnosis, and it is usually advisable to examine such cases bacteriologically and serologically with this possibility in view. The sore then runs a longer course, does not heal, even if kept clean, and after a time the patient presents the characteristic signs of syphilis.

The neighbouring **Lymphatic Glands** practically always become enlarged and tender, and the process is very liable to terminate in suppuration, constituting a bubo. Two forms of this affection are described: (*a*) The simple bubo results from the absorption of ordinary pyogenic organisms from the abraded surface. The pus in this case, if inoculated elsewhere, may produce a pustule, but not a true soft chancre. The process is usually limited to the lymphatic glands themselves. (*b*) The virulent bubo is due to the absorption, not only of pyogenic organisms, but also of the specific bacilli, so that the pus, if inoculated, produces a typical soft sore. In these latter cases suppuration occurs not only in, but even more abundantly around, the lymphatic glands (periadenitis), so that the skin becomes considerably undermined, and the wound produced by opening the abscess may take on the form of a large soft chancre in the groin, in the centre of which is seen the lymphatic gland only slightly enlarged. The process is often slow, and a good deal of cutaneous redness is present with but little pus.

Treatment consists in keeping the sore clean, and covering it with lint dipped in lotio nigra, eusol, or boric acid lotion, healing usually occurring in from ten to twenty days; where much balanitis exists, it may be necessary to slit up the prepuce, but circumcision should not be undertaken until the sores have healed.

Buboes are treated in the early stages by keeping the patient at rest and applying fomentations or Klapp's suction balls, when resolution sometimes occurs. If suppuration ensues, the abscess should be incised vertically, so as to allow free exit to the pus even when the patient is sitting, the cavity being subsequently dressed by packing it with gauze impregnated with eusol or lotio nigra. Some surgeons make small incisions, and trust to the suction effect of Klapp's apparatus; others recommend that the enlarged glands should be freely removed by dissection, but such is not often required. The tissues surrounding them are so extensively infiltrated that it is sometimes impossible to define their limits, and surrounding tissues of importance may be involved. Moreover, complete removal of the lymphatic glands in the groin is sometimes followed by serious evidences of lymphatic obstruction in the limb or external genital organs. Prolonged rest, free incision, and packing with suitable gauze, usually result in a cure; when repair is slow, a visit to the seaside will often be beneficial.

Syphilis.

Syphilis is a specific disease due to a spirochæte* discovered by Schaudinn and Hoffmann in 1905, now termed *Treponema pallidum* (formerly *Spirochæta pallida*) (Plate VI., Figs. 1 and 2). Spirochætes are common in the mouth and in dirty wounds; but this organism can usually but not always (especially in exudates from the mouth, tonsils, etc.) be distinguished from unimportant forms by its morphology and staining reactions. It can be cultivated, as discovered by Noguchi, in a mixture of agar and ascitic fluid containing a bit of sterile fresh animal tissue, *e.g.* rabbit's kidney, under strict anaërobic conditions. Morphologically, it is a very delicate spiral filament, having some eight to twelve fairly regular curves; its ends are sharply pointed, and each terminates in an exceedingly delicate flagellum. Its length varies, but on an average is about equal to the diameter of a red blood-corpuscle or a little more, and each whorl occupies about 1 μ. The common *Tr. refringens*, which is frequently met with in the mouth, tonsils, etc., is larger, broader, has blunter ends, and a smaller number of less regular whorls.

The specific organism can be detected in the great majority of all cases of syphilis; and it may be present in enormous numbers in the

* '**Spirochætes.**'—The exact position and classification of these has been much debated. By some they have been regarded as belonging to the protozoa; but the Society of American Bacteriologists classifies them among the (vegetable) Schizomycetes as the order Spirochætales, and to the two most important genera of these, to which the more important pathogenetic members belong, Dobell suggests that the terms **Treponema** and **Leptospira** should be applied. To the former, *Treponema pallidum* of syphilis, and to the latter, *Leptospira icterohæmorrhagiæ* of infective jaundice and *L. icteroides* of yellow fever, belong.

lungs, liver, spleen, and other viscera of still-born syphilitic fœtuses. In acquired syphilis it may be demonstrated in the earliest stages of the sore which precedes the typical primary chancre, or in scrapings thereof; in the secondary stage it occurs in the skin-lesions, or in the fluid of blisters raised near them, in the lymphatic glands and in the spleen, and has been demonstrated in the blood, though rarely; in the tertiary stage it has been found in small numbers in gummata and other specific lesions, but in the majority of cases it can be demonstrated only with great difficulty and after prolonged search; especially is this the case in the so-called parasyphilitic affections of the nervous system.

Syphilis occurs naturally only in man, but it may be artificially inoculated into the higher apes, which develop a disease comparable in most of its features with human syphilis, and experiments on these animals have yielded results of much clinical interest. The disease has been transmitted by material obtained from the human subject in all stages—*e.g.*, the blood, the semen, discharges from the primary sore, from secondary lesions, and even from gummata. After such experimental inoculation, the incubation-period is from three to four weeks, and then an indurated nodule appears which undergoes ulceration, and is accompanied by enlargement of lymphatic glands. Mild secondary symptoms usually follow, but tertiary manifestations have not been observed. It has been proved that the inunction of calomel ointment locally can prevent infection, even up to twenty hours after inoculation; but removal of the inoculated region has proved useless except when undertaken within eight hours after infection. The rabbit has also been much used for the experimental transmission of the organism, the inoculation being made into the eye or testis.

The most important methods employed in the **Laboratory Diagnosis** of syphilis are the demonstration of the spirochæte and the Wassermann reaction. Other less important methods are various precipitation tests; whilst the detailed examination of the cerebrospinal fluid is often of great importance, especially in the later, but sometimes also in the less advanced, stages of the disease. *Treponema pallidum* can usually be found without difficulty in the serum which oozes from the surface and especially from the margin of the chancre after the surface has been thoroughly cleansed with saline, and then firmly rubbed with alcohol or spirit, which in turn is wiped off with saline; or, after the preliminary cleansing, it may be scarified or slightly cut —bleeding being avoided, or if it occurs, the blood being wiped off until serum alone exudes. This is then either transferred directly with a platinum loop to a ringed slide for examination by dark-ground illumination and other films made in various special ways; or it is collected in a capillary tube for transmission to the laboratory. Puncture of neighbouring enlarged lymphatic glands may also be employed, a little sterile saline being first placed in the syringe in order to wash out the small amount of gland-juice collected in the needle. Long before the sore has taken on a typical appearance the spirochætes

may be thus demonstrated and a diagnosis made. No antiseptic should be applied to the sore before examination. Three methods of demonstration may be employed: (1) The material may be examined fresh under dark-ground illumination. This is considered by many to be the best method, the organisms being easily seen and their characteristic movements observed. (2) Appearances somewhat similar can be secured by mixing the secretion with fluid Indian ink, spreading it out into a film, and allowing it to dry on a slide. Here also the organisms appear colourless on a dark ground, but, of course, there is no movement. This is a simple and quick method; or the material may be mixed wet with 2 per cent. Congo red, dried, blued by exposure to the fumes of strong hydrochloric acid—with no washing at any stage—the spirochætes being silhouetted colourless against the blue background. (3) There are numerous staining methods, most being modifications of Romanowski's; photographic processes depending on the reduction of silver salts are also used, especially when the organisms have to be sought for in the tissues.

In the **Wassermann reaction**, a complement-fixation test (see p. 21), we possess a test which, when positive, is of the greatest value. In syphilis, the reaction is not established immediately, but may first show itself in two, three, or four weeks after the appearance of the primary sore. In some cases it may be delayed till the fifth or sixth week or even later. It is, therefore, essential to examine the primary sore itself for *Treponema pallidum*, before local antiseptic treatment has been commenced. A positive diagnosis may thus be made at once in many cases; and, if there are reasonable clinical grounds for believing the case to be syphilitic, and especially if it is possible to demonstrate the presence of the spirochæte, it is bad practice to await the establishment of a positive Wassermann before commencing treatment—the results of **immediate** treatment being infinitely better than if delayed until the Wassermann reaction has developed. Moreover, in this early stage, a single negative Wassermann reaction is of little value by itself, and the test may have to be repeated several times.

In untreated cases in the secondary stage, the Wassermann reaction is practically uniformly positive, and the result of the test may, in the vast majority of cases, be taken as an accurate indication of the presence or absence of syphilitic infection.

In the tertiary and late stages, a negative Wassermann reaction is never absolutely conclusive. In many cases, a positive reaction may still persist; but, in a certain proportion, it becomes feeble or absent. In a not inconsiderable proportion of old-standing nervous cases, the **cerebro-spinal fluid** may give a positive result, although the reaction in the blood may have disappeared.

For purposes of diagnosis, a positive reaction may, in some cases, be induced by a small 'provocative dose' of salvarsan, etc. It must be clearly remembered, however, that a positive reaction merely proves the presence of a syphilitic infection in the body; it does not prove that a given lesion is syphilitic.

The **Clinical History** of syphilis varies widely in different cases according to the virulence of the infection and the degree of resistance of the tissues, but as a rule the three stages suggested by Ricord are observable. The **primary** stage includes a varying period of incubation, and the appearance of a sore, usually known as a 'hard chancre.' This is followed in the course of a few weeks by evidences of **general** infection, referred mainly to the skin, mucous membranes, and lymphatic glands, comprising the **secondary** stage. After a variable time, perhaps extending to many years, during which symptoms may be absent, **tertiary** manifestations (gummata, etc.) may show themselves in any part of the body.

Mode of Infection.—Acquired syphilis is almost always due to infection of the genital organs by the spirochæte transmitted by sexual connection. Cases, however, also occur in which the disease is acquired otherwise, *e.g.* by direct or indirect contact with syphilitic lesions, and then the primary lesion is often located on some other part of the body (**extragenital chancres**). Thus, the lip may be infected as a result of drinking out of the same glass or smoking the same pipe as a syphilitic patient, or by kissing. It has been conveyed from patient to patient by imperfectly sterilised dentists', hair-dressers', and manicurists' instruments; and to doctors, dentists, and nurses in the course of their work. The spirochæte is a delicate organism, and quickly loses its virulence outside of the body. This probably explains the rarity of infection by indirect contact. The disease is not equally infectious in all its stages; in the primary, the discharge derived from the chancre will alone convey the contagion; in the secondary period the virus is present in the blood, and consequently in all pathological exudates, as also in the semen. It is uncommon, but by no means impossible, for infection to be conveyed by patients in the tertiary stage.

The stage of **Incubation** lasts for a variable period, extending from two to six weeks; as a rule, evidences of induration of the sore can be detected about the third week. Removal or destruction of the local lesion has not the slightest influence upon the progress of the case, unless it is undertaken immediately after infection, or unless the patient is being treated by salvarsan. Many spirochætes are shut up within the chancre, and as these are inaccessible to the drug, it is advisable to remove them by operation. During the incubation period the local sore may heal over superficially, if it is purely syphilitic, and nothing further may be noticed until the typical induration manifests itself. Not infrequently, however, pyogenic infection occurs, or a soft chancre (*q.v.*, p. 161) is also present; in the latter case the lesion does not heal satisfactorily, and the base of the ulcer becomes indurated after a time.

I. **The Primary Stage** of syphilis is characterized by the development of a sore, associated with enlargement of the neighbouring lymphatic glands. The sore is most frequently situated on the prepuce, rather more frequently on the inner than on the outer aspect; it is common in the sulcus between the glans and prepuce; or may

occur on the glans itself or on the frænum; but no part of the male genital organs is exempt. In the female it is most frequently to be found on the inner aspects of the labia majora or nymphæ, but it often causes so little inconvenience as to be overlooked.

The primary sore does not invariably present the same appearance, although it is typically characterized by a certain amount of infiltration and induration. The following are the chief forms in which the chancre manifests itself: (*a*) The **desquamating papule** is a slightly elevated spot, which is irritable, of a dusky colour, and free from ulceration. It is usually small, hard, and its surface covered with epithelial scales. If exposed to friction or to the irritation of retained discharges, ulceration is very liable to occur, with at first but little induration. Unless such ulceration takes place, the disease may run its course unobserved, and thus a patient becomes syphilitic without being able to trace the time or source of infection. (*b*) The **indurated, hard,** or **Hunterian chancre** is that most commonly seen;

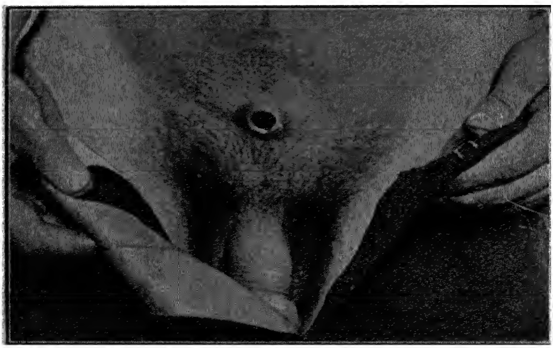


FIG. 33.—HARD CHANCRE OF ABDOMINAL WALL IN SUPRAPUBIC REGION.

it results from the irritation of a papule, or is developed in association with a soft sore. Should the initial surface abrasion have healed, a localised mass of almost cartilaginous hardness forms in the cicatrix, closely adherent to and invading the cutis; but if a soft sore has first developed, the surface remains ulcerated more or less deeply, with a well-defined margin, though the base becomes indurated (Fig. 33). In some cases there may be but little elevation of the lesion, and the surface is free from ulceration, constituting the variety known as the 'parchment induration' of Ricord, and most frequently seen on the glans penis. Where, however, the prepuce or body of the penis is involved, the induration is more diffuse, owing to the laxity of the connective tissue. When affecting the base of the prepuce, the induration usually spreads transversely, producing a collar-like mass, which on retraction of the part rolls back *en bloc* in a very characteristic manner When the orifice of the prepuce is involved, the part becomes diffusely infiltrated and

hard, so that retraction is impossible, and a form of phimosis is thus acquired. Examined microscopically, the new formation consists merely of a mass of round and spindle cells packed closely together, with a certain amount of intercellular fibrous tissue, giant cells, usually smaller in size than those characteristic of tubercle, being sometimes seen. The blood-supply of the part is scanty, a fact which explains the readiness with which ulceration occurs. It is all-important, however, to remember that a diagnosis of syphilis can be made by the microscopical demonstration of the spirochæte long before this typical induration appears, and if such early diagnosis is made, and effective treatment commenced immediately, the likelihood of a complete cure is much greater and the necessary course of treatment less prolonged.

Several chancres are occasionally seen on the same individual if the infection occurs at one time, and it is possible that a patient may be infected at two different periods if only a short interval elapse between the inoculations; but the disease is not generally auto-inoculable, and when once a hard chancre has developed on the inner surface of the prepuce, the glans does not become infected from contact. Multiple chancres are always of small size, and the induration is less marked than usual.

A **Urethral Chancre** is usually situated just within the lips of the meatus, constituting a sore with an indurated base. It may be felt as a hard nodule on grasping the urethra between the fingers, and gives rise to a thin serous discharge, often blood-stained. The orifice itself is sometimes the site of a hard chancre, which may encircle it, and be followed by a stricture.

Extragenital Chancres are most commonly observed on the lip, finger, or nipple. They are often characterized by much infiltration, due to pyogenic inflammation, and less distinct and definite induration than in the forms met with on the genital organs; hence the swelling is more prominent and vascular, and if ulceration occurs there is a greater amount of discharge, which forms a thick scab over the surface. Neighbouring lymphatic glands are often much enlarged, and surrounded by infiltrated tissue. This condition has been mistaken for epithelioma, from which, however, it can be distinguished by the induration and sharp limitation of the sore, its rapid development, and the earlier enlargement of the glands. The course of the case is sometimes more severe than when the primary lesion is in the usual situation, a fact possibly explained by the disease remaining unrecognized till secondary symptoms develop. Digital chancres (Fig. 34) are usually seen in nurses, surgeons, and accoucheurs, and often start by the side of the nail. An indolent sore appears, which becomes infiltrated and ulcerates, spreading under the matrix and along the semilunar fold. There is considerable discharge and pain, and the terminal phalanx becomes swollen and bulbous. The epicondyloid and axillary glands are enlarged as the case progresses. Occasionally, however, the sore has been so small and so little obvious as to be overlooked.

Phagedena, or spreading gangrenous ulceration, is rarely met with at the present time, except as a complication of venereal disease, and seldom apart from syphilis. It attacks unhealthy and debilitated individuals, and is due mainly to the retention of discharges resulting from phimosis. The prepuce and end of the organ become red, swollen, and infiltrated On dividing or retracting the foreskin, the affected surface is found to be sloughy, and the ulceration, unless checked by treatment, rapidly spreads, and may destroy glans and prepuce, and even attack the body of the penis. **Treatment** consists in division of the foreskin if that structure has not already been destroyed, followed by repeated immersion of the patient in a hot hip-bath In the intervals the wound should be dusted with iodoform, and dressed with lint soaked in lotio nigra. The later treatment is conducted as for primary syphilis, although the depressed condition of the general health may necessitate the administration of tonics, etc. Should treatment by immersion in hot water be for any reason impracticable, the old-fashioned plan may be adopted —*viz.*, scraping the sore, and freely cauterising the base with pure carbolic or fuming nitric acid. Possibly, where there is much sloughing, this latter method may advantageously precede immersion in a bath.

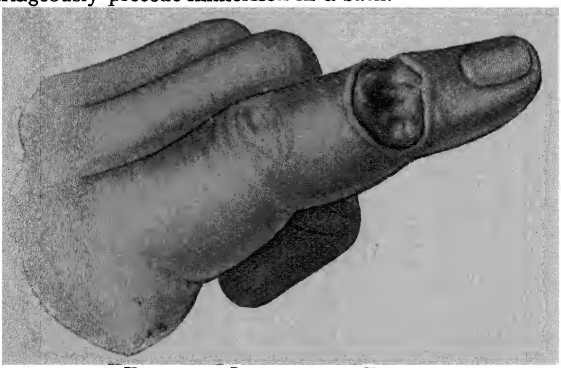


FIG. 34.—CHANCRE OF FINGER.

The **Lymphatic Glands** which receive lymph from the region in which the sore is situated become characteristically enlarged. They are freely movable under the skin and are hard like bullets, nodules of cartilage, or almonds (hence the term 'amygdaloid,' which has been applied to them); they are usually painless, and do not suppurate unless the original sore is inoculated with the virus of a soft chancre or with pyococci.

Occasionally the lymphatic vessels extending from the sore to the glands become the seat of a chronic lymphangitis, and may be felt as hard cords beneath the skin. The dorsal lymphatic of the penis is frequently blocked in this way, and gives rise to solid or lymphatic œdema of the prepuce and glans. Should the chancre suppurate, abscesses may also form in the course of the lymphatics.

The **Duration** of the primary sore varies in different cases, and depends in great measure on whether treatment is commenced early or late. If the patient comes under observation during the first six weeks, and appropriate treatment is at once started, the chancre usually heals over, the induration disappearing in from two to three weeks. The glands in the groin, however, remain enlarged for

some time. The longer the case is left untreated, the more slowly does the induration disappear and, apart from treatment, may last for twelve months or more, and then slowly pass off, although it may run a much shorter course. From an uncomplicated syphilitic sore but little scar results, although a well-marked cicatrix may follow a soft or suppurating chancre.

Re-induration of the cicatrix (**relapsing chancre**) sometimes occurs from too early a cessation of antisyphilitic treatment, or from some localized irritation, or from a fresh exposure to infection. It is occasionally due to a tertiary or gummatous development, and will then be free from lymphatic complications.

II. (A) **Secondary Syphilis.**—In the secondary stage, the virus is diffused generally throughout the body by means of the blood, which is itself infective. A certain amount of constitutional disturbance may exist, the patient feeling out of sorts, whilst in some cases distinct pyrexia, wasting, and headache may be noted. Secondary anæmia, particularly hæmoglobinæmia, well-marked, and sometimes severe, often supervenes, and a moderate lymphocytosis, absolute or relative, is present. The chief secondary manifestations consist in a general enlargement of the lymphatic glands, together with the appearance of various forms of rash on the skin and mucous membranes, loss of hair, and other less common phenomena, involving the eyes, brain, etc.; these usually show themselves in from six to nine weeks from the time of inoculation, although they may be delayed to a much later date. Their intensity varies considerably, the phenomena being in some cases scarcely evident, and in others very marked. They are greatly influenced by the period at which treatment commences; the earlier it begins, the less obvious are the secondary symptoms.

The **Cutaneous Eruptions** of secondary syphilis are characterized chiefly by the fact that, although any form of rash may be simulated, no specially distinctive variety is originated. Moreover, in the same individual the eruption is not always of the same character throughout, several distinct types developing in different parts of the body (polymorphism). The rashes are usually more or less symmetrical (Plate V.), the colour in the early stages being a dusky red, resembling that of raw ham; occasionally, however, they may be a bright rosy red. Syphilitic rashes disappear after a time, but often leave a coppery-brown discoloration of the skin for a while; moreover, they do not completely fade on pressure, but leave a similar brown discoloration, and give rise to but little irritation or itching.

The simplest form consists of a mere hyperæmia, sometimes appearing as a dusky mottling of the skin (roseolous syphilide), which quickly fades or may persist whilst other types are developing. Sometimes distinct papillæ become infiltrated and hyperæmic (papular syphilide); at others, vesicles or pustules appear (vesicular or pustular syphilides); the latter change is uncommon, and only appears in bad cases or in debilitated patients. Another form of

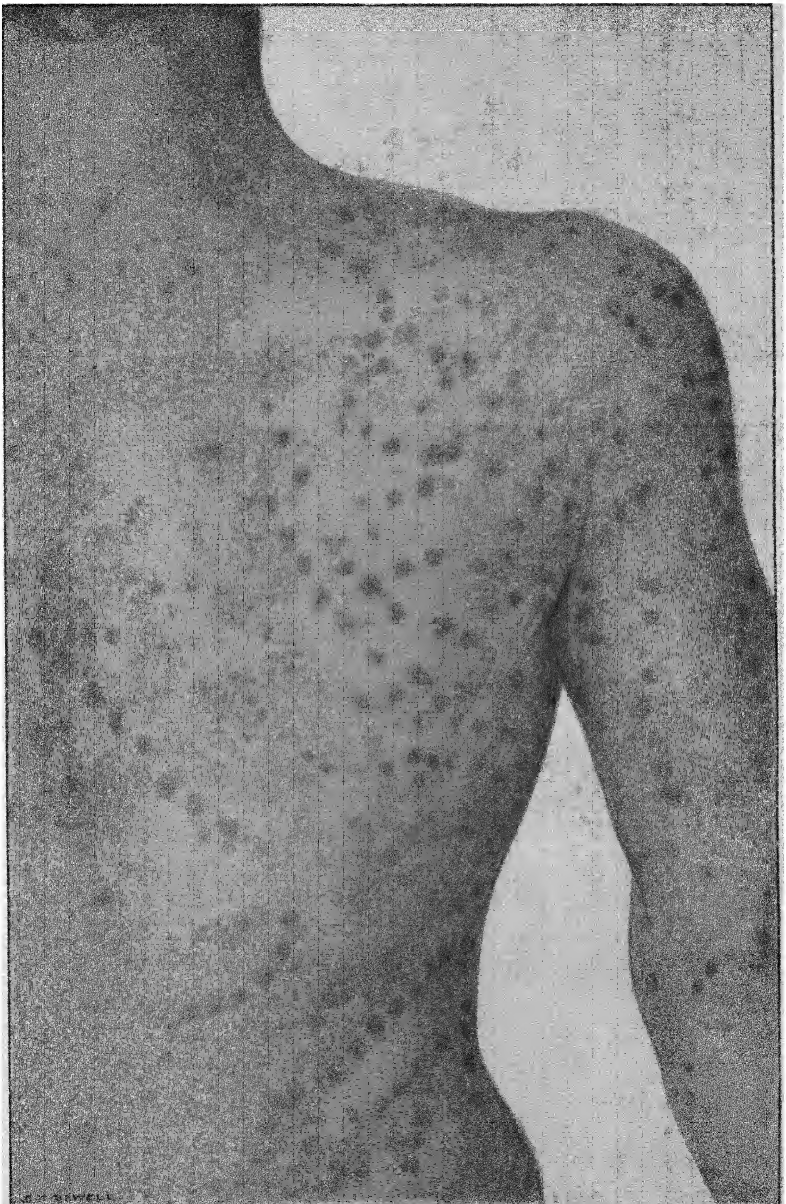
eruption is the squamous syphilide, characterized by patches of hyperæmia and infiltration, combined with superficial desquamation. It is usually bilateral, and, unlike simple psoriasis, affects the flexor rather than the extensor surfaces. In the later stages, distinct nodules are produced in the skin, which may even undergo ulceration ('lupoid' syphilide).

As to the situation of the rash, the roseola is usually limited to the trunk, whilst the other forms are often scattered widely over the trunk and extremities, involving, however, the flexor more than the extensor surfaces of the limbs. A somewhat characteristic phenomenon is the appearance of a papular rash on the forehead, sometimes known as the 'corona Veneris.

The **Mucous Membranes** may be affected in much the same way as the skin. The fauces become red and congested, the hyperæmic area being abruptly limited and semicircular in outline; symmetrical ulceration usually follows, starting near the anterior pillars of the fauces, and spreading to the tonsils and along the soft palate to the uvula. These ulcers are shallow, have sharply-cut edges, and often present a characteristic grayish appearance, constituting what is known as a 'snail-track' ulcer. The secondary sore throat rarely results in extensive loss of substance, and hence pharyngeal stenosis is not produced. Concurrently with these manifestations in the fauces bare patches from loss of epithelium may be seen on the dorsum of the tongue, or several small superficial ulcers may develop on the inside of the cheeks or lips, or along the borders of the tongue, from the irritation of the teeth.

Mucous patches and condylomata are somewhat similar affections, though more pronounced, arising in the secondary stage in connection with mucous membranes and those parts of the skin which are soft and moist. **Mucous patches** consist of slightly-raised areas of enlarged and infiltrated papillæ, white in appearance from the superficial epithelium becoming sodden, and often progressing to actual ulceration. Examined microscopically, the papillæ are found to be definitely enlarged, and the epithelium heaped up over them. They are most commonly observed at the corners of the mouth, on the inner aspect of the cheeks, the side of the tongue, or the margin of the anus; in the last-named situation they are usually symmetrical, one side being infected from the other. They are also not at all uncommon between the toes, and the ulcers caused thereby become exceedingly offensive. **Condylomata** are similarly the result of more marked overgrowth of the papillæ, differing from mucous patches merely in degree. They consist of definite wart-like masses, which may attain a great size, constituting a cauliflower-like growth. They are most commonly seen about the anus or vulva, in the former situation being often mistaken by the patient for piles; they give rise to an abundant, highly infective discharge. A similar condition is sometimes met with on the dorsum of the tongue, and is then known as 'Hutchinson's wart.'

PLATE V.



Cutaneous Eruption in Secondary Syphilis

[*To face page* 170

The **Lymphatic Glands** are usually enlarged throughout the body during this period of the disease, being felt as round, hard swellings beneath the skin. The extent of the glandular complications is possibly a measure of the degree of virulence of the affection. Chronic enlargement, particularly of the nuchal and epicondyloid glands, in the absence of any obvious local cause, is always suggestive of the possible existence of syphilis.

Syphilitic Alopecia.—The hair becomes dull and lustreless, and either comes out in patches from the scalp, eyebrows, beard, etc., or there is a general 'thinning.' The follicles, however, are not destroyed, and after a time the hair will grow again.

Syphilitic Iritis is characterized by pain in the eye, generally referred to the supra-orbital nerve, together with some interference with vision, and possibly a little lachrymation and photophobia. On examination a bright-red circular zone is seen immediately around the cornea, resulting from hyperæmia of the ciliary vessels. The iris is lustreless, and its definition somewhat blurred. Its colour is changed, a blue iris becoming greenish-yellow from the presence of lymph. The pupil is diminished in size, and perhaps irregular; its movements are always considerably hampered, and sometimes entirely prevented, by the formation of adhesions either to the back of the cornea (anterior synechiæ) or to the lens capsule (posterior synechiæ). Occasionally small yellowish nodules are seen on its surface, consisting of plastic lymph.

The **Duration** and character of the secondary stage vary considerably. As already emphasized, the sooner effective treatment is commenced, the less severe the secondary phenomena. Hence the disease is often of an aggravated type when following undiagnosed extragenital chancres, as also in women, by whom the primary lesion often passes unnoticed. When treatment is commenced within four or five weeks of infection, the secondary stage may be slight, and all traces of its existence may pass off in two months or less; if treatment is delayed until the cutaneous eruption has appeared, this stage is likely to last longer. The condition of the patient's health is an important factor, as also the previous habits, particularly as to temperance, since syphilis always follows a more aggravated course in the weakly and the dissipated. Patients suffering from the debility caused by malaria or other tropical affections are particularly bad subjects, and the disease may then run a virulent course. **Relapses** during the first twelve months are usually due to intermissions in or inadequacy of the treatment. The rash which appears under these circumstances is often of a more characteristic type, the papules being grouped into rounded or confluent figures.

II. (B). **The Intermediate or Late Secondary Stage** constitutes a link between the symptoms already described and the tertiary phenomena; no distinct limits to this period can be defined, nor need it appear at all if the patient's general health is good, and the treatment has been carried out regularly. **Later secondary** manifestations include flying pains in the bones, iritis, and various

nervous lesions, whilst periosteal nodes may form on the tibiæ and other bones, or a symmetrical chronic effusion develop within the synovial membrane of joints. Some of the secondary manifestations, especially those of the bones and joints, may persist through this period, whilst even if they have disappeared the patient is liable to suffer from 'reminders' in the shape of various cutaneous affections, and perhaps epididymitis. The bloodvessels are not infrequently affected in this and later stages of the disease, the endothelium of the tunica intima undergoing proliferation (Fig. 348); the lumen is thereby diminished, and the nutrition of the part supplied may be lowered, especially if thrombosis supervenes. Arterio-sclerosis of the larger trunks may be induced by an affection of this type involving the vasa vasorum, and many forms of nerve trouble may be lighted up if the cerebral or spinal vessels, either large or small, are involved. Paralysis of a single limb (monoplegia) may result, or of one side of the body (hemiplegia); but the affection may be limited to a single cranial nerve, or result merely in severe headache. Deep ocular lesions (*e.g.*, choroido-retinitis) are also not unusual. The principal cutaneous affection is a squamous syphilide which may simulate psoriasis in appearance, most frequently seen on the palms and soles. An earlier squamous syphilide is often observed in the secondary stage, but is then symmetrical and readily influenced by treatment. In this intermediate period the lesion may be bilateral or limited to one side, according to whether it appears early or late. In the former there is a considerable tendency to proliferation of the epithelium, together with deep cracks and fissures; in the latter there is less epithelial overgrowth, but the edges are often distinctly serpiginous in outline, and there is an infiltrated border.

Rupia and **Ecthyma** are both met with in this stage of the disease, but only in patients whose nutrition is defective and when treatment has been neglected. They are characterized by an infiltration of the skin (in reality gummatous), which progresses to ulceration. In rupia the discharge forms a distinct scab on the surface, which increases in thickness by the deposit of successive layers, one under the other, each being somewhat larger than the one which precedes it; hence a scab shaped like a limpet-shell is produced, resting on an inflamed and hyperæmic base; any part of the body may be affected in this way. In ecthyma no scab forms over the ulcerated surface, or, if formed, it readily comes away, leaving exposed a hollow punched-out sore, surrounded by an area of vivid congestion. Under appropriate treatment these conditions disappear, but leave depressed, whitish cicatrices, often surrounded by brownish pigmentation.

A somewhat unusual intermediate manifestation is a subacute symmetrical epididymitis, in which the cord also becomes thickened, enlarged, and tender.

III. **Tertiary Syphilis.**—The phenomena occurring in this stage may appear within six months of infection, or not for twenty or

thirty years. They are mainly characterized by infiltration and overgrowth of the connective tissues of the body. This may occur in one or many places, and may be diffuse or localized. When diffuse, the organ or part affected becomes enlarged and hard, and unless the condition is treated promptly, remains permanently sclerosed from the development of fibro-cicatricial tissue. If, however, the process is localized, a **Gumma** is formed.

Any tissue in the body may be the seat of a gummatous deposit, which apparently may arise without any ascertainable predisposing cause, although occasionally its onset may be determined by an injury. The involved area becomes infiltrated with large oval endothelioid cells and small round cells (lymphocytes); plasma-cells are usually present in considerable numbers. The constituents of this mass are similar to those which are found in a tubercle, but

FIG 35.—ULCERATING GUMMATA OVER CHRONIC FIBROID DISEASE OF BURSA PATELLÆ.

without the grouping into small nodules and the more or less orderly arrangement in zones; giant cells may be absent, though their presence is by no means rare, and they may closely simulate, but are usually smaller than, those of tuberculous type. Very few vessels penetrate into the mass thus formed, which otherwise resembles granulation tissue; it gradually increases in size, infiltrating and replacing the normal tissues of the part. The fate of the fully-formed gumma varies according to circumstances. If the infection is a mild one, and especially if appropriate treatment is adopted, most of the cells become absorbed, and the remainder are organized into fibrous tissue; even a large gumma may almost entirely disappear, leaving but a small fibrous scar.

In the absence of proper treatment, most gummata undergo a necrotic change, which commences at the centre of the nodule and

spreads towards the periphery. This may be a comparatively slow process, accompanied by fatty degeneration and caseation somewhat similar to that seen in tubercle; or it may be more rapid, the tissues undergoing a kind of mucoid degeneration, forming a gummy mass from which the lesion acquires its name. Sections through such a gumma will show a large white or slightly yellowish structureless centre of necrotic non-vascular material, surrounded by a zone of cellular tissue, which gradually merges into the normal structure of the part. Two factors are concerned in the production of this necrosis, *viz.*, (*a*) the toxins produced by the causative organisms, and (*b*) the deficient blood-supply of the central portions of the cellular mass resulting partly from syphilitic endarteritis and in part from the associated perigummatous fibrosis almost invariably present.

FIG. 36 - CUTANEOUS GUMMATA OF LEG AND PIGMENTED SCARS.

Under appropriate treatment the whole of the gummatous mass may be absorbed, even when caseation or necrosis has taken place, but not infrequently the gummy, semi-purulent fluid which is formed at the centre of the mass finds its way to the surface and is discharged (Fig. 35). Where the necrotic mass is large, a portion of it may remain adherent to the surrounding tissues after ulceration has taken place, looking somewhat like a piece of wet wash-leather. Occasionally the central slough may become encysted by the formation of a fibrous capsule, and calcification may supervene; this is most frequently found in the brain, testis, and liver.

The appearances of surface gummata vary according to whether they are cutaneous or subcutaneous.

Cutaneous gummata are very frequently observed in tertiary syphilis, especially in the earlier stages. They occur as rounded dusky red nodules of firm consistency, and but slightly painful, and if they break down give rise to typical circular ulcers (Fig. 36). Many such nodules are often grouped together in one region, and when ulceration has occurred they produce by their confluence sores with a rounded or serpiginous outline. Considerable destruction of tissue follows, but they are readily cured, giving rise to depressed white cicatrices, surrounded by pigmentation. Any part of the body-surface may be involved, but a very common site is about or just below the knee on the outer, rather than the inner, aspect of the leg.

Occasionally a diffuse infiltration of the skin is met with in this stage, appearing as a red hyperæmic area with a rounded or serpiginous border, and not at all unlike lupus in appearance (Fig. 37). It spreads rapidly at the margin, which is distinctly thickened, and may contain scattered nodules undergoing ulceration. Whether ulceration occurs or not, a cicatrix is produced. It is readily amenable to treatment, and runs a much more rapid course than lupus; the apple-jelly-like granulations so typical of the latter disease are of course not present.

A **subcutaneous gumma** develops as a firm nodule or an indefinite thickening, which gradually increases in size by the infiltration of surrounding tissues, and sooner or later approaches the surface; the centre of the mass in time becomes elastic and fluctuant; a certain amount of pain and tenderness is noticed, and when the skin is affected it becomes dusky, and even œdematous. If ulceration follows, the contents of the gumma escape, and the sore pro-

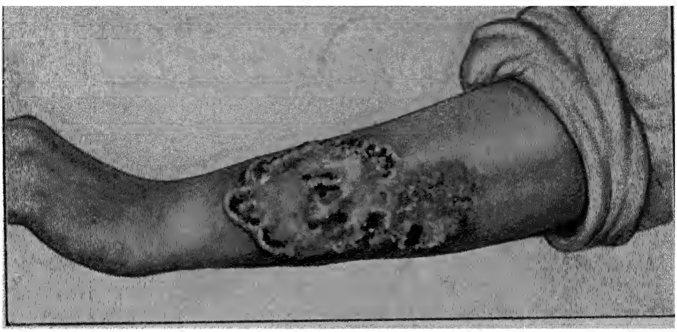


FIG. 37.—DIFFUSE GUMMATOUS SORE OF FOREARM

duced is circular and deep, the edges being sharply cut and perhaps undermined (Fig. 35); the base of the ulcer consists of granulation tissue, although it is sometimes covered by the characteristic slough.

The tertiary syphilitic affections of special organs will be described under the appropriate headings; but the general relation of syphilis to the nervous system (formerly called 'parasyphilis') has been purposely omitted, since it belongs rather to the physician than to the surgeon.

The **Prognosis** of syphilis has become much more favourable of recent years owing to two factors: (*a*) The possibility of demonstrating the presence of the spirochæte in the primary sore, before any typical induration has occurred, has placed in our hands a means of early diagnosis; and (*b*) the employment of salvarsan or its substitutes suitably administered enables us to destroy all the spirochætes which are accessible to its influence.

The question of the possibility of the complete and permanent cure of syphilis has not yet been definitely established, but the

outlook is decidedly promising. A marked feature of modern venereal work is the number of patients coming up for the treatment of hard chancres who have already been treated previously for syphilis. This certainly suggests that modern treatment places patients in a condition in which they again become susceptible to the disease on exposure, an occurrence of extreme rarity in the old days. Whether or not such patients will remain free from the later tertiary affections of bloodvessels (aneurisms, etc.) and of the nervous system (tabes, general paralysis of the insane, etc.) remains to be seen. At the present time all we can say is that the prognosis apparently depends on the following four factors:

1. Early diagnosis.
2. Early and sufficient treatment by the combined use of salvarsan* and mercury.
3. Prolonged treatment with mercury, after the salvarsan course or courses are completed.
4. Return for investigation of the Wassermann reaction from time to time.

A patient who is seen early in the disease and who has been through a course of treatment with salvarsan and mercury should give a negative reaction early in the treatment, but this does not necessarily mean that he has been cured. After the termination of the treatment, his blood, and, as is often necessary and important, the cerebrospinal fluid, should be examined at intervals, and, if there is no return of the reaction after a full year, the probability is that he is cured; and if there is no return after two years, this may be regarded as almost a certainty. Patients who are seen in the later stages of the disease may never give a negative Wassermann reaction, however long and careful the treatment; such patients are probably incurable in the sense that they will always be liable to the development of fresh lesions if they intermit their treatment, but they are not likely to be infective to others, or now to transmit it to their children. A positive Wassermann reaction, therefore, in the later stages of the disease may, in thoroughly treated cases, perhaps be regarded as having a rather less prohibitive significance with regard to marriage than it has in the earlier stages.

Some strains of the spirochæte appear to be more virulent than others, especially those acquired in the tropics, and some individuals are apparently more susceptible than others. Idiosyncrasies preventing the administration of salvarsan, mercury, or iodide of potassium, militate strongly against a favourable prognosis. The state of health of the patient at the time of infection may influence the evolution of the disease, whilst the co-existence of tuberculous disease may render the outlook very unfavourable, especially when the syphilis is inherited.

Death is rarely produced by any of the secondary manifestations alone, except in the virulent forms developed in the tropics; but it is

* The term 'salvarsan' is used here to include the original '606' and its various recognized and efficient modifications.

not uncommon in the tertiary stage, when important viscera, such as the brain, spinal cord, liver, etc., are involved. Affections of the nervous system, such as **tabes** and **general paralysis**, are more likely to be developed in patients whose work entails considerable nervous and mental strain. In certain instances, the infection may be so virulent, especially if there has also been inadequacy or delay in treatment, that it may have to be regarded as practically incurable (**malignant syphilis**)—a condition most often seen in women.

Prophylaxis.—It is probable that syphilis can be prevented by washing the part exposed to infection with a solution of corrosive sublimate or of permanganate of potash, and rubbing in a calomel ointment (30 per cent.), if such treatment is undertaken within an hour or two of exposure. There is, however, the danger that, although the local occurrence of a chancre may be prevented, a general infection may have taken place.

The **Treatment** of syphilis has been transformed of recent years by the discovery and introduction by Ehrlich and Hata of the substance known as **salvarsan,** or '606' (dioxy-diamino-arseno-benzol di-hydrochloride). It is a bright yellow powder slowly soluble in water, and strongly acid in reaction. It may be administered by intravenous or intramuscular injection, preferably the former. The dose for an adult varies from 0·3 to 0·6 gramme, which is dissolved in sterile normal saline solution made with fresh double-distilled water. It is then converted into a sodium salt of the base by adding a quantity of 15 per cent. solution of sodium hydrate just sufficient to redissolve the precipitate formed when it is first added. This solution is then made up to 250 or 300 c.c. with saline solution, and introduced into one of the veins of the arm at the body temperature. The patient must be carefully prepared as for an operation, a purgative being given overnight, and no food being permitted for three or four hours before or after the administration. He must stay in bed for twenty-four hours, or longer if he manifests any evidence of pyrexia, muscular pains, headache, or other type of reaction, and should take things quietly on the day after the dose.

Other compounds have been introduced into the market since 1914—*e.g.*, kharsivan, arseno-benzol (Billon), etc., which are apparently identical with salvarsan, and may be used in its place.

Neosalvarsan, another salt prepared by Ehrlich under the title '914,' which appears in commerce under several other names—*e.g.*, neokharsivan, novarsenobenzol, novarsenobillon (N.A.B.), etc.—is now extensively used as a substitute for salvarsan. It is a bright yellow powder, readily soluble in distilled water, so that only a small bulk of fluid (5 to 10 c.c.) need be given; the solution, moreover, is ready for immediate use, no neutralization being necessary. It readily undergoes decomposition when exposed to the atmosphere, and should not be used if the colour is darkened. The N.A.B. is prepared in ampoules containing doses of 0·3, 0·45, 0·6, or 0·9 gramme of the salt; 0·9 gramme of neosalvarsan corresponds to 0·6 gramme of salvarsan. Allowing for the difference in dosage, the two substances

are regarded by many as equally efficacious, though some hold that the effect of salvarsan is more certain than that of its substitute.

Intravenous injections of N.A.B. may be given either in concentrated or in dilute aqueous solutions. In giving the concentrated solution, the ampoule containing the dose to be injected is filed and broken off at the neck. A 10 c.c. syringe to which a needle is attached is almost filled with cold sterile distilled water and 2 c.c. injected into the ampoule, which is shaken until the contents are dissolved, after which the clear N.A.B. solution is drawn into the syringe and injected into one of the veins of the arm.

It was believed that the effect of these drugs was to destroy all the spirochætes accessible to their influence—*i.e.*, in the circulating blood or in the tissues; but it is perhaps more probable that they act by stimulating the patient's tissues to do so. If the infection has been of long duration, and a certain number of spirochætes have become locked up in the walls of bloodvessels or in the nervous system, they may survive the salvarsan treatment, and consequently a complete sterilization of the system may not occur. It must be clearly remembered that salvarsan has not pushed mercury aside in the treatment of syphilis; it has added an element of safety and security, and thereby has diminished the amount of mercury required and shortened the period of infectivity

The course of treatment recommended by Army surgeons for cases seen in the earliest stages consists in—(1) An intravenous injection of 0·6 gramme salvarsan; (2) five weekly injections of mercurial cream; (3) a second intravenous injection of 0·6 gramme salvarsan; (4) five more weekly mercurial injections; and (5) a final intravenous injection of 0·6 gramme salvarsan. During the war an intensive course of treatment was adopted with good results. The minimum course as laid down by Army authorities consisted in 3·9 grammes of neosalvarsan, divided into seven doses given weekly; the first two doses are 0·45 gramme, and the remainder 0·6 gramme. An intramuscular injection of 1 grain of mercury is also given each week. At the end of this course the Wassermann reaction should be negative, but the mercury should be continued in one form or another for twelve months.*

All cases should be kept carefully under observation for at least a year, and this must include the testing of the blood for the Wassermann reaction, at first every month, and subsequently every three months. The slightest sign of relapse, either clinically or by the Wassermann test, indicates the prescription of a second course of treatment similar to the above. In tertiary syphilis salvarsan is useful in helping in the cure of active manifestations of the ulcerative type, but mercury and iodide of potassium still maintain their position, and must be employed. Over the deep lesions, especially of the parasyphilitic type, salvarsan has but little influence.

* For detailed information as to the modern administration of these and similar drugs in syphilis and its complications, reference should be made to special textbooks.

Occasional bad results have followed the use of these powerful drugs, and a certain small percentage of mortality is always to be expected. Headache, fever and a rigor sometimes develop on the same day as the injection, passing off quickly; they are sometimes accompanied by vomiting and diarrhœa. Jaundice may be noted at a later date, usually not very intense, but occasionally severe and even fatal, being then due to acute yellow atrophy of the liver. Various forms of skin lesion may also occur, varying from a simple herpes to a severe dermatitis exfoliativa, which may be fatal. The percentage of these accidents is, however, decreasing steadily, and with increased experience and improving technique may be expected to fall still lower. They are due in part to the toxic character of the drugs, and in part to the rapid destruction of large numbers of spirochætes in the blood and the setting free of a large amount of endotoxin.

Salvarsan is contra-indicated in cases of albuminuria with casts.

The administration of **mercury** plays an important part in the treatment of syphilis, but it must never be relied on alone unless salvarsan or one of its substitutes cannot be obtained, as even if a prolonged and thorough course of mercury is administered, the results are not satisfactory. Many different methods have been suggested in order that the patient may derive the greatest amount of benefit from the drug with the minimum of inconvenience. (*a*) It is often given **by the mouth,** and preferably in the form of pills, composed of gray powder (grains i.—iii., t.d.s.), or of the green iodide (grain ½—i., t.d.s.). The gray powder may be combined with a little extract of opium or pulv. ipecac. co. if it causes diarrhœa; but this addition is not always needed. (*b*) **Inunction** of the mercurial ointment is also frequently adopted, and with great success, inasmuch as it is less likely to cause digestive derangements. If the ordinary officinal ointment is employed, a portion as large as a hazel-nut is rubbed into the groin or axilla nightly, the part being washed the following morning, and not used again for this purpose for three or four days; if the ointment is made up with lanoline, a somewhat smaller amount is required. This is one of the best ways of bringing a patient rapidly under the influence of the drug. At Aix-la-Chapelle and Harrogate this treatment is a speciality, and is combined with the daily use of sulphur water and baths. The mercurial ointment is rubbed in daily by glass rubbers or the hand, and the course lasts six weeks, being repeated within the year. (*c*) **Mercurial vapour baths** may be advantageously employed where the cutaneous eruption is very extensive. The patient sits naked on a cane-seated chair, and covered with a blanket or specially-constructed cloak reaching from the neck to the ground, and not touching the body; 20 or 30 grains of calomel are placed on a metal plate surrounded by a trough containing about an ounce of water. The water is boiled, and the calomel sublimed, by means of a spirit-lamp placed under the chair. In about twenty minutes all the calomel will be volatilized, and deposited in part upon the skin

of the patient, who perspires freely during the process. He then gets into bed between warm blankets, without wiping the skin. This treatment may be combined with medication by the mouth. (*d*) The **intramuscular** injection of mercurial preparations has much to recommend it, and although alarmists have emphasized the danger of suppuration, salivation, and emboli associated with it, yet increasing experience has proved it to be safe and efficacious in careful hands, and with due regard to asepsis. The satisfactory results following its extensive adoption by military surgeons are strong arguments in its favour. Insoluble preparations of mercury are mainly used, and especially in the form of metallic mercury suspended in a cream (*e.g.* Injectio Hydrargyri Intramuscularis '10 per cent.' according to Lambkin's original formula, or his Mercurial Cream made up with Palmitin, Creosote and Camphoric Acid). The dose is injected deeply into the gluteal region, and the absorption, if slow, is regular, so that it is little likely to cause toxic symptoms.

During the course of mercury, the patient's general health and habits must be carefully regulated; alcohol is forbidden, exercise limited, and strict instructions are given as to keeping the teeth and gums clean. An astringent mouth-wash containing alum and chlorate of potash should be ordered, and it may be necessary to remove or stop diseased teeth, but the dentist must, of course, be informed of the nature of the case. To minimize the risk of throat and mouth trouble, it is wise to stop all smoking for at least six months. The dose of mercury required varies in different individuals, being increased in robust people, and diminished in those who are weak or unhealthy. It should always be pushed until mild effects are produced in the shape of slight tenderness of the gums, but 'salivation' of the patient is undesirable. Full doses are usually required for four or five months, followed by a milder course, which should extend till the end of the first year. It is advisable, however, to insist on a three months' course of mercury twice a year for two and a half or three years.

Symptoms of **mercurialism** are induced in some people by very small quantities of the drug, and hence treatment should always commence with small doses. The gums become soft and spongy, and bleed readily on pressure; salivation follows, or even acute glossitis, whilst the breath becomes offensive. The teeth are loosened and may be shed, and the alveoli may undergo necrosis. Digestive derangements, such as colic and diarrhœa, are also observed. Treatment consists in suspending the drug for a time, and giving a sharp saline purge, whilst the spongy state of the gums is remedied by the use of an alum or chlorate of potash mouth-wash.

Iodide of potassium is essential in the treatment of the tertiary and intermediate stages. It appears probable that its chief action is the removal of gummatous tissue, and that it has little influence upon the causative disease; in order to prevent recurrence, salvarsan or mercury is still required. The dose of iodide should not exceed

5 grains to start with, and is gradually increased, until in some cases 1 drachm four times a day has been reached. Plenty of water should always be taken immediately afterwards to assist in its dilution and facilitate its absorption. A feeling of depression and sinking at the epigastrium is sometimes produced, but may be alleviated by the addition to the mixture of sal volatile (♏xv.) or carbonate of ammonia. Symptoms of coryza often follow, and an acneiform eruption over the shoulders and face, which may disappear on increasing the dose. Occasionally a vesicular, or even bullous, rash is caused by this drug. When large doses are given, bicarbonate of soda or potash must be combined with it, in order to prevent its decomposition by the gastric juice. If mercury is required, it is better to give it in the form of gray powder than to add liquor hyd. perchlor. to the iodide in a mixture, as the latter usually disturbs the digestion. Other drugs, such as sarsaparilla, arsenic, and iron, are often combined with iodide of potassium in the later stages of the disease, and may be useful.

Of late years French syphilologists have introduced **bismuth** as a therapeutic agent for cases which have proved resistant to arsenic and mercury. When administered alone, it causes fairly rapid disappearance of the lesions, but has a much slower effect on the Wassermann reaction. Some preparations are used in conjunction with arsenic salts, whilst others are used alone, consisting of precipitated metallic bismuth in isotonic salt solution. The injections are given every three or four days until a total of twelve to twenty doses have been administered, or until the Wassermann reaction is negative. The injections are all intramuscular, the exact detail of dosage varying with each preparation. The complications to which it may give rise are stomatitis and albuminuria. On the whole, opinion in England is not so laudatory as the French reports; in short, bismuth has not displaced either arsenic or mercury, and may be considered merely an adjunct useful in certain cases where mercury is not tolerated or is not effective.

The **Local Treatment** of syphilitic sores consists mainly in the application of various preparations of mercury. The **primary chancre** may be treated by excision, cauterization, or the use of calomel ointment (30 per cent.), with the object of removing or destroying the spirochætes present in the fibrous interspaces. **Mucous tubercles** in the neighbourhood of the anus or vulva, or between the toes, are best dealt with by keeping them scrupulously dry and clean, and dusting them over with powdered calomel and starch, or by the application of calomel ointment, a piece of lint being inserted between opposing surfaces to keep them from rubbing one against the other. **Secondary ulceration of the throat** does not usually require local treatment, as it soon disappears under the influence of mercury. A mercurial gargle may, however, be employed, or in bad cases the affected parts should be painted with glyc. hydrarg. perchlor. (1 in 2,000). **Superficial gummatous ulcers** are treated by removing the scabs, and applying some form of mercurial

ointment. A determined attempt should be made to keep **deep gummatous ulcers** in an aseptic condition, since the advent of sepsis to such sores, especially if they are connected with bones, makes a marked difference in their progress. In neglected cases the wound may become exceedingly foul, and in chronic cases a hectic temperature and waxy degeneration of the viscera may supervene. When gummata come to the surface and point, they should be opened with the same precautions as are adopted in the case of an abscess, and either dressed antiseptically or their cavity packed with sterile lint or gauze soaked in sterilized lotio nigra.

Inherited Syphilis.

Where the parents are syphilitic, pregnancy may not continue to full time, the mother miscarrying perhaps at the end of six or seven months. The child may be well formed, and may even live independently for a short while, but not infrequently it is still-born, and in many cases macerated; under these circumstances the tissues of the body are often swarming with spirochætes. Miscarriages may recur for several pregnancies, and then a living child be produced. In other instances, however, a living child may be born at full term at the end of the first pregnancy in spite of the syphilitic infection of the parents. This child may show evidences of the disease at birth, but more frequently appears to be healthy, specific manifestations not showing themselves for some weeks. The infectivity of the mother, and the degree of virulence of the disease in successive children, decrease with time, and it is possible that, after five or six years of untreated syphilis, a mother may bear a healthy and untainted child; although infection has been known to be transmitted much later.

Theoretically, infection may occur at one of three periods: (*a*) At impregnation the disease may be conveyed by one or both parents. Infection *ab initio* is likely to be followed by a general development in the tissues, and possibly the cases where the mother aborts early and produces a dead fœtus infiltrated with spirochætes belong to this type. (*b*) During the pregnancy infection of the fœtus may occur through a specific infection of the endometrium, especially involving that portion of the decidua which enters into the formation of the placenta. Normally the fœtal and maternal circulations do not commingle, but when the placenta is diseased it is easy to understand that the spirochætes may pass from mother to fœtus. (*c*) It is possible that infection may be delayed until parturition, the child being infected from the maternal passages. Such an occurrence may explain the absence of symptoms in the infant for some weeks after birth, although possibly this is due to the absorption of protective antibodies (chorionic ferments—Routh) during pregnancy, so that, although the fœtus is infected, symptoms are kept in abeyance. In this connection it is interesting to note that, although infective lesions may be present in the maternal passages, primary chancres

are not seen in infants, who are presumably protected either by previous infection or by the presence of the vernix caseosa.

In some cases the mother has shown no obvious evidence of syphilis, and yet is able to suckle her child without harm, even though there are ulcerating lesions on the child's gums and lips, whereas a healthy wet-nurse develops a chancre of the nipple. This is known as Colles's Law, and was first stated by him in 1837. The immunity of the mother under these circumstances was formerly attributed to the production of antibodies in the fœtus and transmission to the maternal blood; but the researches of Neisser on the higher apes have shown that the serum of a syphilitic subject contains neither protective nor curative substances. Investigation of the Wassermann reaction in these mothers has given a positive result in 90 per cent.; it is therefore practically certain that the maternal immunity is due to a previous mild and unrecognized infection.

The length of time during which a syphilitic patient of either sex retains the power of transmitting the disease to the fœtus is an exceedingly difficult point to determine, and one which is constantly coming before the practitioner, who is asked to decide at what period marriage is safe. The rule of practice generally followed is that no one suffering from syphilis should be allowed to marry until the Wassermann reaction has remained negative and he or she has been free from all symptoms for two years, and even then it is advisable that a mild course of mercury should be given for about three months shortly before marriage.

In a few cases a positive reaction still exists in spite of such treatment, but in the absence of all clinical signs it is probable that the risk of marital infection would be very slight; it would be wise, however, in the case of a subsequent pregnancy to put the mother under treatment.

The question of transmission to the third generation is one of much interest, concerning which a good deal of conflicting evidence has been forthcoming. The dependence of this disease upon a recognized organism, which it has been possible to demonstrate in late tertiary stages, is presumptive evidence in favour of its transmissibility; but, naturally, one of the chief difficulties is the proof of absence of reinfection in the second generation.

At birth the child may appear healthy and well nourished, but is often small and imperfectly developed. The first definite symptoms of the disease manifest themselves at a variable period, extending from three weeks to three months, after birth; the child becomes thin and emaciated; the skin, which hangs in wrinkles over the body, changes to a dull earthy colour; whilst the features look pinched and wizened, like those of an old man. Marked anæmia is always present, and may persist for a considerable time. Speaking generally, the symptoms of inherited syphilis are similar to those of the acquired disease, except that the primary lesion is absent. Thus, during the first year of life the child develops various cutaneous

eruptions, mucous patches, and superficial ulceration of the mucous membranes. A dusky red roseola, especially about the nates (napkin area), may first be noticed, but does not last long. This is usually followed by the appearance of mucous patches at the angles of the mouth, in the nose, and around the anus, as also in the moist folds of the groin, and between the scrotum and thigh. The sores on the lips are sometimes very marked, giving rise to ulcerated surfaces, which, by their subsequent cicatrization, leave radiating scars (or rhagades), especially about the angles of the mouth (Fig. 39). Other cutaneous affections, such as squamous syphilides of the soles of the feet, together with papular syphilides of the body, and a bullous eruption becoming pustular (pemphigus), are also

FIG. 38.—PROFILE OF BOY WITH INHERITED SYPHILIS, SHOWING DEPRESSED BRIDGE OF NOSE AND FRONTAL BOSSES.

FIG. 39.—CHILD WITH INHERITED SYPHILIS, SHOWING RADIATING SCARS ROUND THE MOUTH. (DR. G. F. STILL.)

observed, the last-mentioned, however, occurring only in debilitated infants. A catarrhal rhinitis is a very early and constant manifestation, giving rise to obstructed nasal respiration, or snuffles. This affection is often protracted, going on to ulceration and destruction of the nasal bones and cartilages; their subsequent development is thus prevented or impaired, and hence the bridge of the nose remains depressed and sunken, even when adult life is reached (Fig. 38). Enlargement of the spleen and liver is also common.

Many infants during the first year of life die from malnutrition or marasmus; but if properly treated a considerable proportion regain their health within six or eight months, all the manifestations described above disappearing although their scars may remain.

The child's subsequent development is frequently impaired, and it often retains an almost pathognomonic facies.

After the first year, any of the tertiary phenomena which appear in acquired syphilis may develop, but, in addition to these, peculiar manifestations may be produced, especially affecting the teeth, bones, and cornea; deafness from disease of the internal ear is also not uncommon.

The **Teeth** in inherited syphilis are sometimes very characteristic. The temporary teeth usually appear early, are discoloured, and crumble away. The permanent teeth are often sound and healthy, but are sometimes deformed. The central incisors of the upper jaw are those most particularly affected, but the upper laterals and the incisors of the lower jaw may also be involved. Instead of being broader at the crown than at the root, they diminish in size from root to crown, being stunted, and separated from one another by interspaces. The angles of the crown are rounded off, and a distinct notch, forming a large segment of a small circle, occupies the centre (Fig. 40). The enamel is often imperfectly developed, and hence they decay early. Occasionally they may be shaped like a screw-

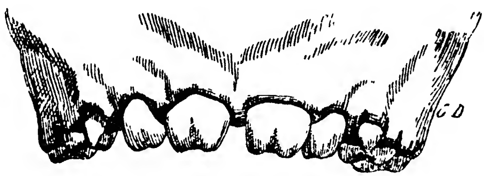


FIG. 40.—HUTCHINSON'S TEETH IN INHERITED SYPHILIS.

driver, narrowing from root to crown, and with a straight free border. The notched and stunted teeth described above are sometimes known as 'Hutchinson's teeth,' but they are not very commonly seen at the present day.

The **Bone** affections observed in inherited syphilis will be described in Chapter XXI.

Interstitial Keratitis, or diffuse inflammation of the cornea, occurs usually about the age of puberty, or earlier. It is limited at first to one eye, but the other is almost certain to be similarly affected at a later date. It commences as a diffuse haziness of the cornea, which looks somewhat like ground glass, associated with hyperæmia of the ciliary region. Red areas, or 'salmon patches,' may be produced in the midst of the opacity, due to a new formation of minute vessels. There is no tendency to ulceration, but in protracted cases the anterior part of the eye may bulge forwards, constituting a condition known as 'anterior staphyloma.' The inflammation may spread to the iris and ciliary body. With suitable precautions the cases usually do well, although treatment for several years may be necessary, and some corneal opacity may persist.

The Wassermann reaction in congenital syphilis is usually positive

in the earlier, more active stages, but in the later it may be diminished or absent, as in the late tertiary stage of the acquired variety.

Where the presence of such infection has not been suspected, the **Treatment** of inherited syphilis should commence as soon as definite manifestations of the disease are present. When either of the parents is known to be syphilitic, treatment must be carried out during ante-natal life through the mother. The general health must be attended to, and if the mother is unable to nurse the child it must be brought up by hand; on no account must it be given to a wet-nurse. Minute doses of arsenical preparations of the 914 type are given at first into the great longitudinal venous sinus, through the anterior fontanelle. The intramuscular route is probably easier than the intravenous, but the latter is desirable for the first few doses. Sulpharsenol is well tolerated by babies.* When the gross lesions have disappeared, mercury must be employed, and is best administered by anointing the under surface of the flannel belly-band with mercurial ointment, or the same preparation may be rubbed into the soles of the feet every night. This should be continued until all secondary phenomena have disappeared, and advisably until the child is two years old. It is sometimes wise to replace this by the internal administration of gray powder, gr. ½ or i. t.d.s., with a little sugar. Cod-liver oil may also be ordered with advantage in some cases, and every possible means adopted to improve the general nutrition. When tertiary symptoms appear, iodide of potassium and mercury should be given in suitable doses.

The local treatment of external lesions is conducted according to the rules laid down for the acquired type of the disease.

Tuberculosis.

Tuberculosis is an infective disease, the causal organism of which is the tubercle bacillus, the name being derived from the characteristic nodules or ' tubercles ' usually present in the tissues.

Predisposing Factors.—The direct transmission of the infection from the mother to the child *in utero* is probably very rare, the fact that there are families in which tuberculosis is specially prone to occur being due rather to the combination of circumstances facilitating the direct infection after birth of the children of tuberculous parents. Unfortunately, tuberculous individuals often have a considerable degree of philo-progenitiveness, and may be remarkably prolific. Although tuberculous disease is most frequently seen in children or young people, no age is exempt from its attacks, even elderly people being affected. These senile manifestations differ in no way from those met with in the young.

A depressed condition of the general health is a very important predisposing cause of tuberculosis. Thus not infrequently the trouble

* 'Treatment of Congenital Syphilis in Children.' Nabarro, *Lancet*, June 5, 1926.

starts in children after attacks of the exanthematous fevers, or as a sequel of rickets, or other childish ailments. Many of these leave an inflamed condition of the pharynx or intestine, and thus provide a suitable entrance for the bacillus. Even in adults the debilitating effects of influenza, a neglected cold, or persistent overwork may be followed by the development of the disease.

Still more is this likely to happen if the patient lives in unhealthy or bad hygienic surroundings. Hot and ill-ventilated workrooms, dark, dirty dwelling-houses never bathed in sunlight, overcrowded schoolrooms, etc., are themselves harmful by lowering vitality, but they often become hotbeds of infection if once consumptive patients are admitted and contaminate the air by coughing and expectorating. This probably explains the terrible frequency with which tuberculous trouble occurs in many places where one would expect the inhabitants to be particularly healthy—*e.g.*, some of the holiday resorts of Scotland, Wales, and Ireland; the houses are small, dark, often dirty, and so hopelessly devoid of ventilation, that if tubercle bacilli once gain an entrance, they become virulently effective in producing disease. Naturally, tuberculosis is most common amongst the poor, but it is only too frequent in the well-to-do.

A local nidus in the body suitable for the development of the micro-organism usually exists, although tuberculous infection very occasionally follows wounds and punctures in previously healthy parts. Thus, chronically inflamed lymphatic glands form a suitable breeding-ground for the bacillus, as also bones and joints in a state of congestion resulting from slight and often overlooked injuries.

The ultimate exciting cause of tuberculosis is the development within the tissues of the *B. tuberculosis* of Koch (Plate VI., Figs. 3 and 5). It usually occurs in the form of slender rods, straight or slightly curved, about 4 or 5 μ in length and 0·2 or 0·3 μ in width, but sometimes forming filaments. The occasional occurrence of branching in old culture suggests that the organism may be allied to the streptothrices. This is interesting in view of the close clinical resemblance between tuberculosis and other diseases due to streptothricial infections, *e.g.* actinomycosis. The tubercle bacillus is a typical 'acid-fast' or, more correctly, acid-proof, organism, and when stained by the Ziehl-Nielsen method appears in the form of slender red rods, which are often stained only in part, so that they seem to consist of short red lengths alternating with unstained areas. *In vitro*, on suitable culture-media, they develop very slowly, two or three weeks elapsing before growth is visible, and require a temperature approaching that of the body and an abundant supply of oxygen. The colonies consist of yellowish-buff, white, or gray scales, which have a dryish look.

A distinction is now definitely established between the human and the bovine varieties of *B. tuberculosis*, and the types of the disease produced by each. Both can develop in human beings, but the bovine variety is mainly responsible for intestinal and surgical

forms of the disease—*e.g.*, those attacking glands, bones, and joints —whilst the human variety leads usually to pulmonary phthisis and to acute general tuberculosis. Cultural distinctions are readily established by the use of egg media, the bovine variety growing scantily, and the human form abundantly, especially in the presence of glycerine. The results of inoculation experiments in rabbits also differ, in that human tubercle produces but little effect and rarely kills, whereas the bovine virus is actively fatal.

The organism gains access to the body in any of the following ways:

(*a*) **By inhalation.** The sputum of consumptives may contain vast numbers of tubercle bacilli, and, as drying does not immediately kill them, living bacilli frequently occur in the dust and in the air. But little advance will be made towards stamping out this disease until consumptive patients can be prevented from expectorating in public places. Even more important is the fact that in coughing and talking the tuberculous sputum is expelled in a state of very fine division, and the infective particles remain suspended in the air for long periods. It is therefore obvious that the strict enforcement of suitable regulations is necessary for the protection of the public from this disease. Tuberculosis acquired by inhalation usually manifests itself in the form of pulmonary disease, but may appear as an affection of the cervical, mediastinal, and bronchial glands, from which the infection may be disseminated to other organs.

(*b*) **By ingestion**—*e.g.*, of infected milk from cows with tuberculous disease of the udders. This is by no means rare, and, in some parts of the country, very common in children, the bacilli entering through the tonsils or other lymphadenoid tissues of the pharynx and invading the cervical glands, or passing through the stomach unharmed and infecting the intestine and mesenteric lymph-glands. Examinations of tuberculous material from the cervical glands in 72 cases in Edinburgh resulted in the discovery that in 65 (*i.e.*, 90 per cent.) the bovine bacillus was present.* Facts such as these indicate the urgent need for some effective control of the milk-supply.

(*c*) **By inoculation.** This is very unusual, and occurs chiefly in pathologists, post-mortem room porters, butchers, etc., in the form of a wart-like tuberculide, known as a verruca necrogenica or post-mortem wart (p. 266). A few cases of tuberculous infection from an accidental cut inflicted by a broken sputum-cup have been recorded.

The laboratory diagnosis of tuberculosis is conducted on one or more of the following lines:

1. By the microscopical identification of the tubercle bacillus after staining by the Ziehl-Nielsen method. When the finding is negative, perhaps on several occasions, it may be necessary to have recourse to other methods.

2. Inoculation of susceptible animals, especially guinea-pigs, is a

* Mitchell, *Brit. Med. Journ.*, January 17, 1914.

most delicate test. The material is usually inserted beneath the skin of the groin, and the animal killed in three weeks, when, if the test is positive, the lymph-glands and probably the internal organs will be found tuberculous.

3. A characteristic of most tuberculous exudates is the presence of small lymphocytes or lymphocyte-like cells as the prevailing type, and, though in syphilis and certain other infections this is also the case, it is a point of considerable diagnostic value.

4. In some cases a portion of the lesion may be excised and submitted to microscopical examination, which should include a search for bacilli, since other infections may give rise to lesions resembling those of tuberculosis.

5. Tuberculin (as originally prepared by Koch) is obtained by evaporating down a six-weeks old glycerine-broth culture of the organism, killing it by heat, and filtering. This filtrate has been used as a diagnostic agent. When injected in suitable amount into a healthy person, it produces no effect, but in tuberculous persons a sharp rise of temperature occurs in a few hours. This test, as also Calmette's method of instilling diluted tuberculin into the conjunctival sac, is not devoid of danger, and a safer procedure is that known as Von Pirquet's skin-reaction, which is apparently free from danger. It consists in inoculating a small superficial scarification with a drop of tuberculin, pure or diluted 1 in 10. The positive reaction consists in the development in from twenty-four to forty-eight hours of a violet-red papule with a characteristic regular or festooned margin. It persists for five or six days, and then fades away. There is no accompanying fever. This test is of considerable value, especially in children up to twelve years of age. The intracutaneous injection of diluted tuberculin is, perhaps, a more delicate method.

6. The opsonic index, though of scientific interest, is now seldom used for diagnostic purposes (see p. 20).

7. Finally, complement-fixation tests are at present unreliable.

Pathological Anatomy.—The most characteristic lesion is the **miliary tubercle,** a cellular mass varying in size up to 2, or perhaps 3, millimetres in diameter. When young and cellular, tubercles are soft, translucent, and of a gray colour, tending later to become caseous, yellow, and opaque.

A typical fully-formed tubercle without retrogressive changes can best be studied in sections from the meninges in tuberculous meningitis, or from the liver or kidney in a case of general tuberculosis. In the centre of the mass there is usually a giant-cell (Fig. 41), the diameter of which may be many times that of a red blood-corpuscle. It has usually an oval or circular shape, though its outline may be very irregular; it has many oval nuclei, and these tend to be arranged round the periphery of the cell. Around the giant-cells there is a zone of endothelioid cells, usually somewhat oval in shape, and their nuclei closely resembling those of the giant-cell. Beyond this is a third or outer zone of small round inflammatory cells, which are usually regarded as identical with lympho-

cytes. It must be understood that all tubercles do not conform exactly to this typical description. The giant-cell, for example, is frequently missing, especially in acute cases, or there may be several cells of this type. Moreover, the width of the zones varies greatly; in some cases the endothelioid cells may appear to be absent, but can be detected among the lymphocytes, which may extend to the centre of the tubercle.

In the production of a tubercle, the bacilli appear to gain access to a lymph-space or to a small vessel, where they set up an overgrowth of the endothelial cells which constitute the middle zone. The giant-cell appears to be composed of a mass of these cells, in

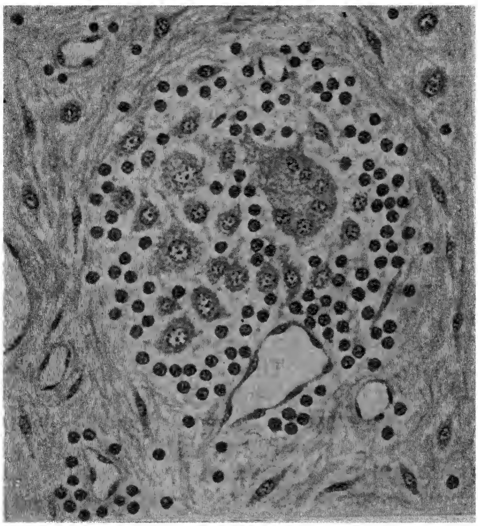


FIG. 41.—EARLY TUBERCLE-FOLLICLE IN SYNOVIAL MEMBRANE.

A small multinucleated giant-cell, about a dozen endotheloid cells, and numerous small lymphocyte-like cells are shown. (× 300.)

which the nuclei have undergone repeated divisions, but the cytoplasm has remained unsegmented.

Miliary tubercles may be embedded in practically normal tissues, but in most cases an inflammatory process can be traced beyond the nodules. It may be of a chronic type, with an increased formation of fibrous tissue; but in the more active forms the intervening structures disappear, being replaced by granulation tissue, which is often œdematous and of a gelatinous appearance. This latter is especially frequent in tuberculosis of the bones and joints. The inflammation also involves the smaller vessels, and particularly the arterioles, the lumina of which may become greatly narrowed, or even entirely obliterated, by a process of endarteritis. True tubercles

may also be produced in the vessel-walls, but this is much rarer. In either case the vascular affection diminishes the blood-supply of the tuberculous mass (already defective owing to the non-vascularity of the tubercles), and increases the likelihood of degenerative changes, such as caseation.

The changes which may take place in a fully-formed tubercle vary, according to the virulence of the bacilli and the resisting powers of the patient:

1. When the bacilli are but slightly virulent and the patient's susceptibility moderate, the tubercle undergoes **fibrosis**; this is the natural method of cure.

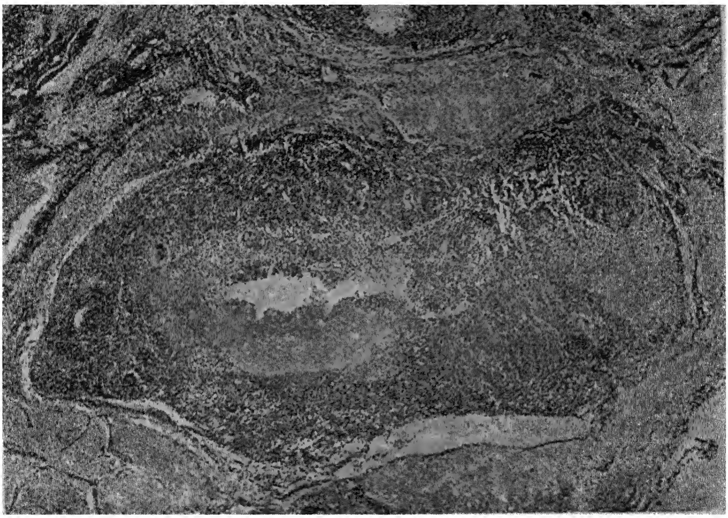


FIG. 42.—EARLY STAGE OF TUBERCULOUS ABSCESS IN LYMPHATIC GLAND. (× 30.)

In the centre is a caseating focus on the point of suppurating; outside it granulation tissue, in which several giant-cells can be seen, and external to this a zone of fibro-cicatricial tissue.

2. When the bacilli are virulent and the patient in a non-resistant condition, **caseation** occurs. This is a necrotic process by which the affected tissues are transformed into a uniform structureless mass staining only with acid dyes, such as eosin (Fig. 42). Though acid-proof tubercle bacilli may often not be demonstrable microscopically in this material, it may be proved to be infective by the production of tuberculosis in animals inoculated with it.

Cure may take place at this stage by a process of fibrosis of the surrounding parts, so that the caseous mass becomes walled in by a zone of fibrous tissue, the cheesy material gradually dries up, and may become calcified. It is possible, however, that the living

organisms may persist in such dried-up caseous material, and, under suitable conditions, recrudescence may ensue, even after an interval of years.

3. In most cases in which caseation is present, the process continues to spread, and involves, not only the tubercles, but also the intervening tissues; in this way cheesy masses of considerable size may be produced. Not infrequently an exudation of fluid takes place into this mass, and the result is a chronic **tuberculous abscess.** Such chronic abscesses may supervene in any affected tissue, but occur most frequently in bones, joints, and lymphatic glands.

The pus from such an abscess consists of disintegrating caseous necrotic material mixed with a variable quantity of fluid, so that it is sometimes thin and milky, sometimes so thick that it will scarcely flow through a cannula. It often contains masses or flakes of curdy débris, and on microscopical examination a few lymphocytes may be seen, together with large quantities of amorphous granular material. Tubercle bacilli may be numerous in the more active cases, but in chronic forms they are often very scanty, or possibly cannot be demonstrated without inoculation experiments. In old-standing cases cholesterol crystals are present, and may be recognized by the glistening sheen or greasy appearance imparted to the pus; microscopically, they appear as flat rhomboidal plates with one corner notched out.

Secondary infection with pyogenic bacteria may supervene, and although the pus in such a case may not differ appreciably from the ordinary pus of an acute abscess, the fact that it contains tubercle bacilli can be demonstrated by inoculation.

The structure of a tuberculous abscess wall is characteristic. The cavity is lined by a layer of gray, yellowish-gray, or pinkish, pulpy tissue, containing miliary tubercles, perhaps undergoing caseation. Its colour and vitality are dependent upon the chronicity or otherwise of the process; the longer the abscess is in forming, the less vascular the membrane, owing to the associated sclerosis of the surrounding structures leading to compression of the bloodvessels, and to the accompanying chronic endarteritis. This lining membrane, when necrotic, is but loosely connected with a layer of fibro-cicatricial material, which forms the outer part of the wall, and from which it can be readily detached.

A chronic abscess forms a soft fluctuating swelling which gradually increases in size, and may become painful by exerting pressure on nerves or other sensitive structures. Should it be **superficial,** it will probably come directly to the surface and burst; the pus and caseous detritus will be discharged, and possibly, if the general health is good, the wound may slowly granulate and heal; but not infrequently the tuberculous tissue left behind prevents healing, and a **tuberculous ulcer** develops. A similar condition is found in connection with mucous membranes, the tuberculous foci starting in the submucosa, and subsequently bursting through the mucous mem-

brane. Whatever their location, the ulcers are characterized by an irregular and ragged margin with undermined and congested edges (Fig. 43, C); the base is formed by pulpy granulation-tissue containing caseous foci, which must be removed before healing can occur.

On the other hand, a **deep abscess** is likely to burrow along fascial planes, and may become superficial at a distance from its original source—*e.g.*, in a psoas-abscess due to tuberculous disease of the spine. The far-reaching extent of these abscesses, the impossibility of dealing adequately with the lining-membrane or with the original focus, render them difficult to treat, and fully account for

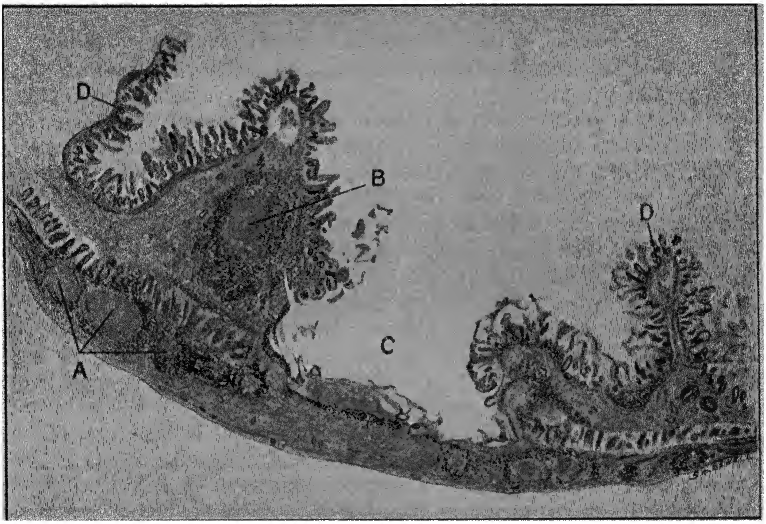


FIG 43 —TUBERCULOUS ULCERATION OF ILEUM. (AFTER MACCULLUM)

A, Subserous tubercles undergoing caseation; B, submucous tuberculous abscess, C, tuberculous ulcer, D, intestinal villi covered with normal mucous membrane.

the dread of opening them experienced by surgeons in pre-antiseptic days; for under the best of circumstances a sinus is liable to develop and persist, and without the most scrupulous precautions pyogenic infection is likely to ensue, followed by an increased discharge of pus, aggravation of the original disease, and only too frequently death from chronic toxæmia (p. 75).

Natural Cure.—A tuberculous abscess, if left to itself, does not necessarily come to the surface. Occasionally one meets with a mass of putty-like consistency lying in front of the spine in the body of a patient who has been cured of spinal disease. This is evidently the desiccated remains of a chronic abscess, the fluid portion having been absorbed, and the solid elements left behind, encapsuled and perhaps

infiltrated with lime-salts. Such débris can become the seat of a recurrence of inflammation years later, when suppuration may suddenly occur, giving rise to what is known as a 'residual abscess.' Probably a large amount of cholesterol will be found among its contents. The prognosis of such an abscess is good, and a cure may often be obtained by one tapping and free lavage.

One of the chief dangers of tuberculous disease is its great tendency to diffusion, which may occur (*a*) locally, by direct continuity of tissue, *e.g.* from the epididymis by way of the vas deferens to the prostate and seminal vesicles, or by extension along neighbouring lymphatics or bloodvessels; or (*b*) distant organs or tissues may become infected, probably by embolic dissemination in the bloodstream. Thus, phthisis is a not uncommon sequel of a similar affection of bones, joints, or lymphatic glands, whilst meningeal tuberculosis is more frequently associated with tuberculous affections of the genital organs. (*c*) Moreover, any tuberculous lesion may lead to acute general tuberculosis, in which the disease is widely diffused throughout the body, giving rise to rapid emaciation, high fever of an intermittent type, and usually severe diarrhœa, dyspnœa, and delirium or coma, death ensuing in a few weeks.

Treatment.—When Koch first discovered the tubercle bacillus, a great impetus was given to operative treatment, and some authorities went so far as to maintain that every particle of the diseased tissue must be extirpated with as much care as in the case of cancer. The pendulum has now swung slowly back, and we are relying more and more on the natural powers of repair inherent in the patient, and are endeavouring rather to maintain and increase these in every way by suitable general and local treatment.

1. **General Treatment** of the sanatorium type is indicated in all cases of tuberculous disease. Residence at a bracing seaside place is desirable, but equally good results can be secured in hilly districts provided that they are not too heavily wooded. The wards or rooms should be so placed as to secure abundance of sunshine; the presence of a wood so as to give shelter from cold winds is useful; and the soil must be sandy, so as to dry quickly after rain. The establishments at Alton in England, Berck-sur-mer in France, Leysin in Switzerland, and at Canton, Mass., in America, are models of what can be done in this direction. Failing sanatorium treatment, it is wonderful what exposure to the sunshine and air in suburban gardens, or even on town roofs, will do. Heliotherapy (p. 309) applied generally to the body, or locally to the affected part, is most valuable, or in the absence of sunshine exposure to ultra-violet rays, as obtainable from an arc or mercury-vapour lamp. In these careful dosage is required, until immunity from harmful effects has been secured. Indications of improvement are shown, not only by loss of local pain, but also by a more regular and normal temperature, increasing weight, improvement in the hæmoglobin-content of the red cells, a slight but definite lymphocytosis, and pigmentation of the skin. If the skin remains un-

affected, it is probable that some active focus of disease is still present. Care must, of course, be taken to protect the patients from cold in winter, as by electrically heated beds and suitable clothing, and they must be given an abundance of nutritious food, such as milk, cream and eggs, in addition to fresh meat (not too much cooked), fat bacon and other commodities which tend to increase the patient's weight. The amount of exercise (when permitted) must be strictly limited, so as to conserve the patient's energies towards the cure of his disease, and in this connection it is well to point out that prolonged rest in a spinal carriage is suitable for many conditions other than disease of the spine or lower extremities. The internal administration of cod-liver oil, of the phosphate or iodide of iron, organic preparations of iodine, guaiacol, arsenical compounds and other tonics, is also useful on occasion. In the case of children, arrangements must be made to provide educational facilities.

As already mentioned, many forms of tuberculin have been introduced since the failure of Koch's original variety as a therapeutic agent, most of them involving the trituration of the bacilli so as to include the endotoxins. The human and bovine forms are both prepared in this manner, and a combined variety is also obtainable. Opinions vary much as to the value of this method of treatment, but in surgical cases where efficient sanatorium treatment is possible, its use is not indicated except when improvement does not occur. Under such circumstances, in a child, 0·00001 milligramme given hypodermically may be employed to start with, increased gradually up to 0·001 milligramme, whilst an adult may start with a dose of 0·0001 or 0·0002 milligramme. It may also be administered by mouth, and seems to act quite well. The injections should not be repeated under ten or fourteen days, and should never be attempted when a mixed infection is present. In some cases good results follow, but in many the effect is disappointing, and in all its use must never supersede the hygienic and surgical measures required in the treatment of the disease.

2. **Local Treatment (Non-operative).**—In the first place, all tuberculous foci must be kept free from irritation, whether extrinsic or intrinsic. Thus, whenever possible, the affected part must be maintained at rest from both movement and pressure. Joints should be immobilised by plaster of Paris or suitable splints; the effect of the weight of the body minimized by recumbency or other means when the disease affects the spine or lower extremities; a tuberculous testis should be supported by a suspensory bandage, etc. Every precaution should be taken to prevent the occurrence of a mixed infection. A patient with glandular infection in the neck should be carefully treated for any peripheral septic lesions, *e.g.* of the lips, teeth and gums, the ear, nose, scalp, etc.; enlarged tonsils and adenoids should also be removed, inasmuch as bacteria are often lodged in the crypts of the former or between the lamellæ of the latter.

These measures may be supplemented by counter-irritation—*e.g.*, blisters, iodine paint, or Scott's dressing, and Bier's method of passive congestion (p. 40).

3. **Operative Treatment** is required when the measures indicated above have failed to check the disease, or when accidental complications—*e.g.*, abscesses—develop in the course of the case, or when the disease is so extensive or progressive as to make it inadvisable to trust alone to the natural processes of repair. Obviously, **extirpation** of the tuberculous focus, if practicable, is the ideal treatment in all cases, and for some conditions no other treatment need be considered, as when the epididymis is seriously involved. In superficial lymphatic glands in the neck excision is the best treatment whenever progress to recovery is delayed or absent. In many other conditions, as in bone and joint disease, total extirpation is practicable by excision or amputation; but such a proposal involves the consideration of many other questions, such as the operative risk, the possibility of a general diffusion of tuberculous material by the necessary manipulations, the possible infection of the wound or surrounding healthy tissues by tubercle, and the degree of post-operative disability that may result. The cure by a local excision is not always certain, and the after-treatment is often very prolonged. On the other hand, Nature's cure may be equally uncertain, possibly less satisfactory, and the chances of dissemination and diffusion are not absent. The final decision as to the advisability of undertaking a radical operation of this type must be made by a careful consideration of (1) the stage of the disease, whether early or late; (2) its position and extent; (3) its character, whether active and progressive, or chronic; (4) the probable resisting power of the patient to the spread of the disease; and (5) the hygienic conditions, etc., under which treatment has to be undertaken.

Partial operations are sometimes required, consisting in cutting or scraping away as much of the diseased tissues as is practicable, swabbing out the cavity thus produced with some powerful germicide, such as liquefied carbolic acid, and dressing the part with gauze soaked in some antiseptic substance, such as an emulsion of iodoform, the wound being left to heal by granulation. Diseased bones, glands, and sinuses have sometimes to be dealt with in this way, and satisfactory cures may be established after a while. Open-air treatment must be instituted at the same time, or commenced as soon after as possible. Theoretically, it is better to do the operation in the country rather than in town, but, of course, this is not always practicable.

When the patient has more than one focus of disease—*e.g.*, pulmonary phthisis at the same time as disease of some joint, or of the testis—it is often found that no progress is being made towards recovery, in spite of what appears to be suitable treatment. It may then be advisable to remove, if possible, one of the foci, when steady, and perhaps rapid, repair may show itself in the other.

The manifestations of tuberculosis as it affects **special organs** are

dealt with elsewhere under the appropriate headings (see diseases of skin, bones, joints, lymphatic glands, kidney, testis, etc.).

The Treatment of Chronic Tuberculous Abscess must necessarily vary considerably according to the position and condition of the part. A superficial chronic abscess is comparatively easy to treat, but one placed deeply, and connected with such an affection as tuberculous disease of the spine, must be approached with the utmost caution, in order to avoid pyogenic contamination.

1. In a few cases of superficial chronic abscess, especially when connected with lymphatic glands, it may be possible to *dissect out the whole cavity en masse*, and if this be feasible, it is the most satisfactory plan to adopt.

2. When the skin is thin and undermined, and the abscess nearly pointing, it is hopeless to avoid leaving an open wound; and hence the condition must be treated by the *open method.* The cavity is freely incised, diseased tissue scraped away, unhealthy skin removed, and the cavity, if not too large or deep, treated with pure carbolic acid or chloride of zinc (gr xl ad ℥i.), packed with gauze infiltrated with iodoform, and allowed to heal from the bottom, Healing is often slow, but *a tuberculous abscess ought never to be allowed to reach a condition in which it is necessary to leave an open wound* of this type.

3. When a chronic abscess is situated deeply and covered with healthy tissues, treatment consists in evacuating the cavity in such a manner as to prevent the formation of a sinus, if possible.

This is best accomplished by means of *Aspiration*, the needle of the aspirator being introduced from the side when practicable The most thorough aseptic precautions are, of course, maintained, and the vacuum should not be too complete so as to avoid too rapid a withdrawal of the fluid, which might result in hæmorrhage. Slight external pressure will assist in emptying the abscess. If the fluid re-collects, the process may be repeated

Sometimes the content of the abscess is so solid that it cannot flow through the needle, and then the latter should be withdrawn and replaced by a trocar and cannula of sufficient size to allow the cavity to be irrigated with warm saline solution (105° to 110° F.). The abscess wall is gently kneaded so as to detach curdy material and necrotic pyogenic membrane. This is continued until the escaping fluid is nearly clear or only slightly opalescent, and then the cannula is withdrawn and a deep stitch introduced to close up the track. In this way it is often possible to cure a chronic abscess by one aspiration. The treatment is most likely to be efficacious when all active bone or joint disease has disappeared, and residual abscesses are the most favourable of all. Formerly this treatment was associated with the introduction of some drachms of a sterilized emulsion of iodoform in glycerine (10 per cent.), but it is doubtful whether this addition was really effective.

Where the disease is more active, it is often wiser to make an incision into the abscess sufficiently large to introduce the finger. Through this opening diseased bone can possibly be removed and the lining wall scraped, and for this purpose a Barker's flushing gouge is often useful. The instrument consists of a gouge or sharp spoon with a long hollow handle, which communicates by a tube with a reservoir of fluid placed at some height above the patient. During its application the constant rush of water or lotion through the handle clears the gouge and removes the débris. It is admirably adapted for certain cases, but its use needs considerable care, as the sharp edge can readily scrape through an abscess wall or lay open a vein. If much bleeding occurs, the cavity should be irrigated with hot sterilized salt solution. The wounds are subsequently closed after a careful application of 'B.I.P.P.' (p. 90), and an attempt is made to gain immediate healing of the denuded cavity by bringing the sides into apposition by suitable pressure. Not uncommonly the cavity refills in the course of three or four weeks, and may need to be emptied by aspiration. It is possible that in such cases a sinus develops sooner or later, and has to be dealt with by simple drainage.

It is often a matter of considerable difficulty to secure the healing of a *tuberculous sinus*, owing partly to the existence of diseased bone or other trouble at its extremity, partly to defective drainage, and also in part to the existence of tuberculous tissue in its wall; the added presence of a pyogenic infection will still further delay healing. Not infrequently sinuses of this type burrow widely, and it is sometimes difficult to ascertain the extent of the mischief with a probe. In such cases help may be obtained by injecting the sinus with 'B.I.P.P.,' or with a paste consisting of bismuth subnitrate 1 part and white vaseline 2 parts, and examining the extent of the lesion by radiography. This process has the advantage of hastening healing of the sinus owing to the chemiotactic, bactericidal, and astringent influence of the paste. In acute suppurative lesions, or where large cavities are involved—*e.g.*, in empyema—this proceeding should not be employed, as toxic effects may follow, and even cause death; the removal of the bismuth paste for such poisoning is hastened by injecting the sinus with warm oil. Of course, where there is much discharge, effective drainage must be provided, but efficient general treatment will usually secure healing in time, without recourse to operative measures directed to removal of the diseased bone, which may come away in small spicules.

Glanders.

Glanders is primarily a disease of the horse, ass, or mule, which is transmitted to men by direct inoculation, and hence is usually seen in stable attendants and those brought in contact with such animals. The disease is due to *Bacillus mallei*.

In **Horses** and other animals glanders manifests itself by a formation of larger or smaller rounded swellings in the mucous membrane of the nose, which break down and ulcerate, giving rise to a thin, sero-purulent discharge, and perhaps to destruction of the bones and cartilages. The lymphatic glands, especially those under the jaw, early become enlarged, constituting the 'farcy buds' of farriers, which by their ulceration may leave ragged, foul, suppurating sores. The lymphatic trunks to and from the glands are involved ('corded veins'), whilst the lungs and internal viscera may also be infected, and undergo destructive changes. The disease is often chronic, lasting perhaps for years; any undue strain put upon the animal may lead to an acute exacerbation, which may be fatal in six to twelve days.

In **Man,** glanders generally starts about the hands and face, but occasionally in the nasal mucous membrane. In **acute** cases the incubation period lasts from three to five days, and is succeeded by the occurrence of malaise and febrile disturbance, followed by severe pains in the bones and joints. The site of inoculation becomes swollen and angry, whilst the lymphatics leading from this to the nearest glands are enlarged and inflamed. An eruption of papules, which somewhat resembles those of small-pox or an iodide rash, occurs around the primary lesion, on the face, and in other parts of the body; but each papule, as also the primary lesion, breaks down and goes on to the formation of an ecthymatous-looking ulcer. It is not an uncommon feature of these sores, when placed over a bony surface, to involve the periosteum and lay bare the subjacent bone. Similar changes occur in the viscera, muscles, and joints, and these being associated with high fever of an asthenic type may suggest the existence of pyæmia. In such cases death may ensue in seven to ten days.

In **chronic** glanders similar symptoms are met with, but the course is slower; there is little or no fever; the disease is less extensive, and intermissions are not uncommon. It may affect the nasal mucosa, leading to chronic ulceration, but more commonly it appears in the shape of chronic abscesses, which often extend deeply, even down to the bones, and are very difficult to treat. In one case the disease gradually spread down along the peronei muscles, and in spite of repeated scrapings and the application of pure carbolic acid, the process was arrested only at the point where the peroneus longus disappears into the foot.

It is important to determine the **Diagnosis** as early as possible, in order to undertake energetic local treatment. The local lesions are distinguished from

small-pox by the presence of the characteristic bacilli in the discharge, by the fact that they involve the subcutaneous tissues more extensively, and by the absence of umbilication. Chronic cases resemble *syphilis* and *tuberculosis*, but the history of exposure to infection from animals suffering from the disease is most important, as also the result of cultivations made from the discharge. When the bacilli are grown on potatoes, a colony of a yellowish, honey-like character forms in two or three days, which gradually turns to a chocolate-brown colour. Inoculation of the peritoneal cavity of a male guinea-pig with some of the secretion leads to acute orchitis in two or three days, the testicles being enlarged and the skin over them reddened; the affection usually runs on to suppuration. Mallein, a sterilized culture of the organisms, may be used for diagnostic purposes in animals, the injection of a minute dose causing a sharp febrile reaction if glanders is present. It has also been used in man.

Treatment in acute cases can be successful only when undertaken early, and before general infection has ensued. The local foci should be thoroughly extirpated, either by the knife, or by scraping and applying some active cauterizing agent. The same treatment must be adopted in chronic cases, and may then need frequent repetition. The use of immune serum and vaccine is also recommended by some authorities.

Leprosy.

Leprosy (*syn.: Lepra*, or *Elephantiasis Græcorum*) is a general infective disease due to *Bacillus lepræ*, characterized by the formation of granulomatous masses, which arise primarily in connection with the skin and nerves. Unlike the tuberculous granuloma, these nodules are vascular, contain no giant-cells, and are comparatively small in size in relation to the number of bacilli present.

The bacillus of leprosy resembles that of tuberculosis, and, like it, is Gram-positive and acid-proof, staining readily by Ziehl-Neelsen's method, though, as a rule, more easily decolorised than are tubercle bacilli. Leprosy bacilli are usually smaller, straighter, and more uniform than those of tubercle; and when seen in sections of leprous material they are often present in far larger numbers than are the tubercle bacilli in tuberculous tissues; they are mostly situated within the large granulation-tissue cells ('lepra cells'), and often show a characteristic grouping as if packed together like bundles of cigarettes (Plate VI., Fig. 6). Numerous attempts have been made to cultivate them, and a few doubtful successes have been claimed. Attempts to inoculate animals have failed, or at best have been inconclusive, and this test constitutes the best and most definite method of differentiating between the two diseases.

Leprosy, though formerly common in this country, is now observed only in imported cases. In Iceland, Norway, Russia, and the East, it is still frequently met with, although the method of segregation of lepers enforced in Norway has greatly diminished the number in that country. It is apparently very slightly contagious to adults, the medical attendants and nurses in leper hospitals rarely contracting the disease; inoculation experiments on criminals have led to negative results. The children of leper parents are not diseased at birth, but are very liable to contract it at an early age; this fact emphasizes the urgent necessity for separating the children from their diseased parents at the earliest possible date.

Symptoms.—Two chief varieties of leprosy exist, *viz.*, the nodular, and the maculo-anæsthetic; but the two are often associated.

Nodular or **Cutaneous Leprosy** is the form most commonly seen in Europe. Nothing may be noticed for months or years after exposure to the contagion, and then, after a period of malaise, associated with dyspepsia, diarrhœa, and drowsiness, a distinct febrile attack is noted, lasting for days or weeks; it may be ushered in by a rigor, and the temperature is usually of a remittent type. This is followed by, or associated with, the appearance of shiny, red, hyperæmic spots, which are from the first infiltrated, slightly raised, and hyperæsthetic; they are usually situated on the forehead or cheeks, on the outer side of the thighs, or on the front of the forearms. They may fade away and

disappear entirely, and then again become evident, or fresh patches may be developed, and always with febrile symptoms. After a variable period numbers of little pink nodules form over the site of one or more of the erythematous patches, and these gradually increase in size and coalesce, until possibly they become as large as a walnut or hen's egg, and are then of a brownish-yellow colour. Almost any part of the surface of the body may be invaded in this manner, but the face is especially prone to be involved, and the resulting disfigurement is very marked, a curious leonine appearance being

FIG. 44 —LEPROSY. (FROM A PHOTOGRAPH KINDLY LENT BY W. THELWALL THOMAS, ESQ., OF LIVERPOOL.)

The patient had lived as a sailor, and contracted leprosy abroad many years before. The facial aspect is very characteristic, and the forearms are enlarged owing to leprous deposits in the subcutaneous nerves.

imparted to the features (Fig. 44). The nodules are more or less anæsthetic from the pressure of the infiltration on the nerves, and the ultimate result of the process may vary considerably; resolution sometimes occurs, or the nodules may be transformed into depressed and pigmented cicatrices, or ulceration may ensue. Visceral complications and enlargement of the lymphatic glands follow, any fresh deposit being associated with febrile phenomena. The sexual organs and their functions are usually affected in this form. Death may occur from general spread of the lepra bacillus itself,

but is more commonly due to some intercurrent malady such as pneumonia, dysentery, renal disease, etc.; the patient may, however, live for many years.

The nodules consist of masses of granulation tissue, and scattered through them are numbers of large cells, containing multitudes of bacilli.

Maculo-Anæsthetic Leprosy is the form more commonly met with in hot climates. The earliest phenomena consist in a certain amount of malaise without appreciable fever, together with sharp tingling or lancinating pains and tenderness along the course of certain peripheral nerves. The ulnar, median, peroneal, and saphenous nerves are those most often affected. This is followed by muscular weakness, running on finally to paralysis, various modifications of sensation, and trophic phenomena, involving at first only the skin, but later on attacking bones, joints, and muscles. Circular yellowish-white patches are observed in the skin, spreading peripherally, and tending to run together, forming large irregular ovals; the border is often raised and hypersensitive, but the central portions become atrophic, dry, white, and anæsthetic. The anæsthesia gradually spreads, and serious lesions, partly due to trauma, partly arising from trophic changes, result. The muscles atrophy and contract, and give rise to deformity, the hands sometimes becoming markedly 'clawed,' as in ulnar paralysis. Interstitial absorption of the bones of the peripheral portions of the limbs may lead the fingers, toes, and other portions to shrivel and disappear, preceded by ankylosis of the joints. The affected nerves can usually be felt distinctly enlarged and tender, Visceral lesions are not so marked in this as in the other form of the disease, and the patient may retain a considerable degree of health and strength, while his sexual powers are not much interfered with. Finally he dies from general debility, or from various complications, but the case may last twenty or more years.

Treatment.—The earlier in the disease this has been undertaken, the more favourable have been the results obtained. The intravenous injection of ethyl esters of chaulmoogric and hydnocarpic acids, or of sodium hydnocarpate ('alepol'), sodium gynocardate 'C,' and other derivatives of chaulmoogra oil have been used with marked success, and also creosoted hydnocarpus oil given intramuscularly or subcutaneously, alternating with some of the foregoing. Protein-shock (*e g.*, with T A B. vaccine), and treatment with a vaccine prepared from the bacilli contained in excised leprous tissues (Norman Walker), have also been favourably reported upon in a few cases. Treatment should be maintained for at least a year to be effective, and must be associated with good sanitary conditions, nourishing food, and protective dressings containing powdered chaulmoogra seeds in an ointment Hopelessly damaged limbs may still require amputation. For full details of the treatment, special textbooks may be consulted.

Actinomycosis.

Actinomycosis is a disease of man and cattle, due to infection with various types of a group of streptothrices called actinomyces (or ray fungus), occasionally also occurring in a bacillary form. The characteristic pathological process is the development of a granulomatous mass around a colony, which after a time breaks down, suppurates, and discharges pus containing small pale yellow to greenish-gray or brownish bodies, the so-called 'sulphur granules.' The structure of these bodies can be made out by crushing the particles between two slides and staining the film thus produced. Each colony consists of a tangled mass of Gram-staining mycelium (Plate VI., Fig. 7), the peripheral portion often having a definite radial arrangement. The mycelial filaments which project from the outer portion of the colony may show 'clubbing' from degenerative thickening of their sheaths.

The structure of the granuloma resembles in some respects that of a tubercle, giant-cells being perhaps less frequent, and the centre of the nodule occupied by a characteristic colony of the fungus. The disease tends to extend locally, but a pyæmic spread may supervene and important organs be attacked.

It is commonly supposed that the organism reaches both man and cattle on infected barley or other cereals, fragments of which may stick in the gums

by the side of the teeth, or about the pharynx or œsophagus, or may be swallowed

Actinomycosis in **Cattle** most commonly affects the tongue or jaw, and causes a chronic fibrosing inflammation ('woody tongue,' 'big jaw,' of cattle) (Plate VI, Fig 8), often suppurating and producing multiple chronic abscesses, which discharge externally and leave a diffuse inflammatory mass riddled with sinuses

In **Man** the disease occurs especially in farmers, millers, and others who are brought in contact with grain, though in some cases it is difficult to trace any such connection. In many cases the primary lesion may be in the neighbourhood of a carious tooth or tonsillar crypt. Less frequently it may occur in other parts of the alimentary canal, especially in and around the cæcum or appendix, or in the liver, giving rise to a very characteristic reticulated swelling, in which diffuse suppuration may occur. Again, it may attack the lung, causing lesions and symptoms which may simulate those of tuberculosis, and often giving rise to localized empyema The skin may also be affected, but in the majority of cases only by extension from the deeper tissues.

The commonest site for the primary lesion is close to the angle of the jaw, where it constitutes a cervico-facial growth of tolerably characteristic appear-

FIG. 45—CERVICO-FACIAL ACTINOMYCOSIS. (BY KIND PERMISSION OF THE LATE SIR MALCOLM MORRIS)

ance. At first the mass has a smooth, regular, and even surface, and merges gradually into the surrounding tissues, the skin over it being usually hyperæmic. The absence of lymphatic glandular involvement is of important diagnostic significance. As time passes, little nodular excrescences, with a characteristic yellowish apex, form here and there on the surface of the mass, and these finally soften, point, and burst, giving exit to a small amount of thick gelatinous pus, in which the actinomyces may be demonstrated. When all the mycelium has been discharged, the abscess contracts and the wound closes. The cicatrization induced by the constant repetition of this process gives to the surface of the mass the peculiar nodular and puckered appearance, which, when present, is almost pathognomonic (Fig. 45). At other times sinuses persist, and the affected area may become riddled with them. Trismus is an almost constant symptom in the cervico-facial form of the disease, coming on early, and being apparently independent of the size of the mass or its involvement of nerves.

Treatment consists in the administration of large doses of iodide of potassium (commencing with 20 to 30 grains three times a day, increased even to ʒii. four times a day). If open sores are present, iodides are of less value, and surgical measures must be employed. Any attempt to extirpate the whole mass by cutting or scraping is probably of little use, as reinfection of the exposed tissues is likely to occur. Probably the local incision of foci as they

soften and the removal of the contents by gentle friction with a gauze swab is the best plan to adopt, followed by drainage assisted by hypertonic salt solution. Vaccine-treatment holds out considerable prospect of help, the vaccine consisting of an autogenous or stock growth of *Actinomyces bovis*, together with such other organisms as may be present in the secondary infections. For thoracic and abdominal cases, X-ray therapy is often useful.

CHAPTER VIII.

TUMOURS AND CYSTS.

REVISED BY W. E. CARNEGIE DICKSON, M D., B.Sc., F.R.C.P.E.

ALTHOUGH the term 'tumour' is often used for any abnormal swelling which may be met with in the body, yet for scientific purposes its application is much more limited. A tumour may be defined as 'a mass, of new formation, that tends to grow or persist, without fulfilling any physiological function, and with no typical termination.' The fact that it has no typical termination distinguishes it from inflammatory overgrowths, which always lead sooner or later to the formation of fibro-cicatricial tissue or some modification of it; inflammatory growths, moreover, may disappear completely, and often diminish in size temporarily. Pure hypertrophies are excluded by this definition, since they always depend more or less on some increased physiological function, and are composed of an increased development of normal tissues, as, for instance, the blacksmith's biceps. Congenital overgrowth of a limb or portion of a limb also occurs, and is known as 'gigantism'; it cannot be considered a tumour, being merely an exaggerated development of normal tissues.

Ætiology.—In a certain number of cases the occurrence of tumours has been described as having followed upon some **injury** or **irritation.** Thus, an adenoma of the breast may be attributed to a blow, though this may merely have called attention to its presence. The irritation of a clay pipe has been thought to play some part in the production of epithelioma of the lip. In Kashmir the natives wear under their robes an earthenware pot or kangri, suspended from the waist, and containing smouldering charcoal; the heat of this leads to chronic eczema of the abdominal wall, and this is in turn frequently followed by squamous-celled carcinoma. In some cases the irritation may be due to chemical substances such as soot (in the case of chimney-sweeps), tar, or petroleum, all of which occasionally lead to the production of epithelioma in persons brought much into contact with them; in these and certain analogous cases, **occupation** and **environment** may thus play some part in the causation of tumours.

Heredity was formerly thought to be of considerable ætiological importance, especially in malignant disease, but recent observations and statistics have not strengthened this view.

The **age-incidence** varies with the type of tumour. Most innocent forms may occur at any age. Sarcomata also occur at all ages.

They are much commoner than carcinomata in the first half of life, though in both types the case incidence increases with advancing age. Carcinomata are rare before the age of thirty, and most common after forty.

The effect of **sex** on the incidence of the innocent tumours and the sarcomata is not marked. Women are more liable to carcinomata than males, in large measure owing to the frequency with which this disease attacks the uterus, ovaries, and breast; cancer of the mouth and other portions of the alimentary canal is more common in men.

Many hypotheses have been brought forward to explain the **pathogenesis** of tumours, but their actual causation is still unknown. It is quite possible that Cohnheim's hypothesis of **Embryonal Residues** may explain some instances, as may also the analogous hypothesis of tissue-intermingling suggested by Virchow, and based on the observation that in the ossification of cartilage small islets are sometimes left in the midst of the growing bone and retain their fœtal structure; these, he suggested, might subsequently grow and develop into chondromata. Similarly dermoid cysts originate in portions of epithelial tissue left behind during intra-uterine life; and it is conceivable that in many tissues in the body there may be residues consisting of embryonic cells in a latent condition, but which, as the result of a suitable stimulus, either irritation from within or external injury, may wake into activity and develop along lines which will produce a tumour composed of tissues into which the fœtal cells would have developed had their evolution been normal.

With further reference to the origin of malignant growths, see also pp. 221 and 231.

Tumours may be divided into two great classes from a clinical standpoint, *viz.*, the benign and the malignant, with, however, all intermediate varieties.

Benign or **Simple Tumours** are characterised by their more or less definite limitation, being frequently encapsuled, and by their method of growth. The surrounding tissues are merely pushed aside and compressed by the increasing growth of the tumour, pain and atrophy are sometimes caused by this pressure. The capsule is formed by an ensheathing layer of fibro-cellular tissue, the outcome of the chronic irritation and inflammation engendered by the growth; hence enucleation may be easy, and recurrence uncommon. They are not infrequently multiple, and may be congenital; but there is no tendency to produce secondary growths. They cause no cachexia and do not threaten life unless developing in or upon some part whereby the vital functions are impaired.

Malignant Tumours, unless removed by operation or in some cases successfully treated by radio-therapy (p. 226), are almost invariably fatal. The following are the chief characteristics of malignancy; (1) The primary growth is usually single, rarely multiple. (2) It progresses continuously, but with varying rapidity in different cases. (3) The local development is characterized by an infiltration of the surrounding tissues, which are gradually destroyed

and replaced by the tumour. A capsule is rarely formed, or, if at all, only in the early stages, and thus the limits of the growth are not clearly defined. Moreover, many varieties spread locally along the lymphatics draining the area involved, and hence, although the growth may appear to have been completely excised, 'recurrences' are very common, owing to the non-removal of these invisible extensions of the disease into apparently normal tissue. If a malignant tumour with all its ramifications is completely removed, it does not recur. (4) When a malignant tumour invades the skin, it usually leads to ulceration and is very liable to secondary infection with micro-organisms, and then not uncommonly a foul fungating mass results. (5) Secondary deposits due to embolic dissemination of the cells of the growth are often found in neighbouring lymphatic glands or distant viscera. (6) Cachexia develops in the later stages, partly due to the pain, partly to the pressure of the growth on important structures, and in part to the absorption of toxic products from the tumour. The patient becomes thin and emaciated, the face drawn and with an expression of pain on it; the appetite is impaired and the skin often sallow and earthy-looking. Pyrexia is usually absent unless ulceration of the growth occurs, as is usually the case in the stomach or intestine; some rapidly-growing sarcomata of bones are also associated with fever. (7) Finally, death supervenes after a longer or shorter period.

The **degree of malignancy** varies with different tumours. In some the local phenomena predominate, whilst in others the constitutional symptoms are the more important. Thus, rodent ulcer is slow in its progress, and produces no visceral deposits; if it destroys life it does so merely by extension of the primary growth to vital parts. Melanoma, on the other hand, may produce only a small primary growth, but the most extensively diffused secondary deposits may form in the viscera. The sarcomata are usually disseminated by the blood-stream, and hence secondary growths are not so common in lymphatic glands, whilst the carcinomata spread especially by means of the lymphatics. Even among the latter considerable differences are manifested; thus, in glandular cancer, secondary growths occur both in the lymphatics and the viscera; whilst in squamous epithelioma neighbouring lymphatics are affected, but the viscera usually escape.

As a general rule malignant tumours differ structurally from the innocent forms in deviating more widely from the normal histology of the region in which they develop; thus, a simple fibro-adenoma of the breast approaches more closely to the structure of the normal mammary gland than does an adeno-carcinoma of the same region. This deviation from the normal is called **anaplasia,** and in general the greater the degree of anaplasia the greater the malignancy. It is seen in the structure of the cells as well as in their arrangement, and in highly malignant tumours the constituent cells to a large extent lose their distinctive appearances, and revert to more simple forms. Highly specialized functions are also lost or badly performed.

Classification of Tumours.—Of the various classifications which have been suggested, that of Adami is the simplest and most convenient. Two main groups of tumours are first distinguished:

Teratomata (including placentomas), or tumours 'composed of the products of one individual within the tissues of another individual of the same species.'*

Blastomata, or tumours 'composed of the product of aberrant growth of the cells and tissues of the individual in whom they are developed.'

The latter group of **Body-tissue Tumours** is then further subdivided. From each of the three primitive embryonic layers, epi-, meso-, and hypo-blast, are derived two types of tissues, **pulp-tissues** and **covering-** or **lining-tissues** (**rind-tissues**); and, from each of these, tumours both simple and malignant may grow. The pulp-tumours derived from all three layers present so many analogies with one another, both clinical and pathological, that they may be considered together, and divided further into those which are **simple,** and those which are **malignant**; and a similar division of the rind-tumours may be made (with the *previso* that there are all intermediate stages between the definitely 'simple' and the definitely 'malignant' tumours of both sets; and also that, in the case of certain meso- and endo-thelial tumours, a reversion from covering- and lining- to pulp-tissues may take place†). For the detailed descriptions of individual tumours, reference may be made to pathological textbooks or special works upon neoplasms, and only a short account of the more important varieties can be attempted here, under the following headings:

A. Blastomata or Body-tissue Tumours.

I. Pulp-tumours.

(1) *Simple or Typical:*

Fibromata.	Odontomata.
Myxomata.	Myelomata.
Lipomata.	Lymphomata.
Chondromata.	Myomata.
Chordomata.	Gliomata.
Osteomata.	Neuromata.

(2) *Malignant or Atypical ('Sarcomata'):*

The malignant tumours corresponding to the foregoing, together with those derived from *meso-* and *endo-thelial* tissues, in which there is reversion to 'pulp' characters. (Along with this group will be considered the *Melanomata*, pigmented tumours of doubtful origin.')

* There is no reference here, of course, to the experimental implantation of tumours in animals.

† For a detailed description and explanation of such phenomena and a full account of Adami's 'Classification of Tumours,' see Beattie and Dickson's 'Textbook of Pathology,' 3rd edition, pp. 280, 285, and Appendix II.

II. **Rind-tumours** (derived from covering and lining tissues).

(1) *Simple or Typical:*

Papillomata	Hæmangiomata.
Adenomata.	Lymphangiomata.

(2) *Malignant or Atypical:*

Cancers or carcinomata (including epitheliomata, malignant adenomata, etc.).

Endo-, meso-, and peri-theliomata, etc., in which the 'rind' characters persist.

B. **Teratomata (including Placentoma and Teratoid Tumours).**

A. Blastomata or Body-tissue Tumours.

I. Pulp-tumours.

(1) Simple or Typical.

Fibromata consist of overgrowths of fibrous tissue; they are usually divided into two groups, the **hard** and the **soft,** and, although there is no essential difference, it is a useful clinical distinction.

The **Hard Fibroma** is composed of firm dense tissue, which creaks on section with the knife, the exposed surface showing numerous trabeculæ of glistening fibres, somewhat similar in appearance to those present in a tendon (Fig. 46). Microscopically, interlacing fibrils are seen, which are sometimes arranged concentrically around the bloodvessels. There are comparatively few nucleated cells in the more slowly growing tumours (Fig. 47). The vascular supply is somewhat defective, although dilated veins are often present in the capsule, and sometimes in the substance of the mass; these, if opened by ulceration, may lead to profuse hæmorrhage. Hard fibromata may occur in many situations, but especially in the breast and ovary, and in tendons, the cerebral membranes, etc., not uncommonly in the sheaths of nerves, or as fibrous polypus of the naso-pharynx, as one variety of epulis, or in the form of keloid.

Soft Fibromata develop as localized overgrowths of the subcutaneous fibro-cellular tissues, and may be rapid in their development, and then somewhat resemble a sarcoma, or slow in their growth, approximating more to the type of a lipoma (Fig. 48). Sometimes they become more or less pedunculated, constituting what is known as a molluscum fibrosum, and then may appear as rounded, smooth-topped nodules; or may be pink in colour and covered with somewhat corrugated skin, looking like a nipple; or may develop into large pendulous folds.

In the latter instance the condition is possibly a manifestation of neuro-fibromatosis (p. 220).

Myxoma.—A myxoma is a tumour consisting of connective-tissue cells, surrounded by and separated from each other by an intercellular substance of a mucoid character; a similar type of material occurs normally in the substance of the umbilical cord. The cells are usually polygonal in shape, and present long branched processes which interlace with those from adjacent cells. The intercellular substance is homogeneous and translucent, and is traversed by imperfectly formed bloodvessels; the density of the tumour varies inversely with the amount of intercellular substance. It is not uncommon for a somewhat similar myxomatous condition to occur

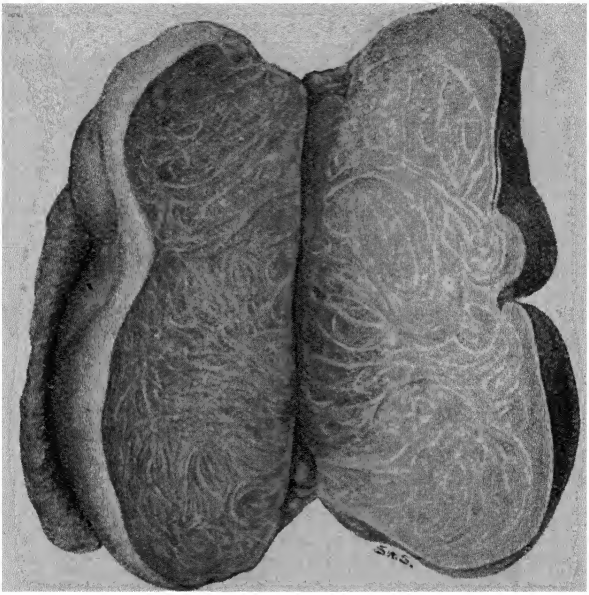


FIG. 48.—SECTION OF HARD FIBROMA. (ROYAL COLLEGE OF SURGEONS MUSEUM.)

as a secondary change in sarcoma, and hence a thorough and early removal of the mass is always advisable.

Myxomata occur as rounded tumours, perhaps lobulated, in the subcutaneous or submucous tissues, *e.g.* of the breast, face, intestine, and bladder; they also grow in the sheaths of nerves.

Lipoma.—A fatty tumour is an overgrowth of fatty areolar tissue. On microscopical examination it differs in no respect from ordinary adipose tissue, and is not very freely supplied with bloodvessels.

When **localized** (Fig. 49) it forms a tumour, soft and semi-fluctuating in consistence, rounded and lobulated in outline, and, if occurring in the subcutaneous tissues, the skin becomes dimpled on moving it from side to side, owing to the fact that fibrous trabeculæ pass from the septa and capsule to the skin. The growth is usually encapsuled

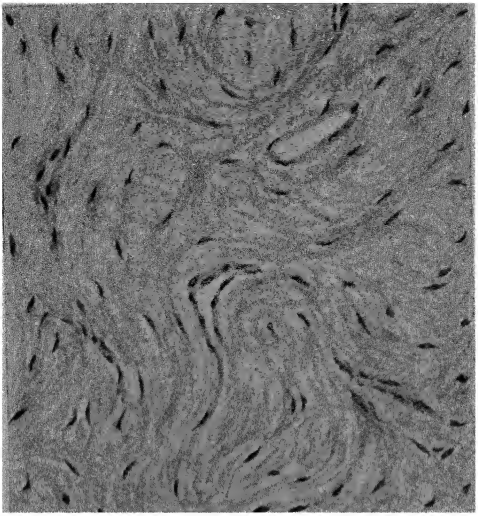


FIG. 47.—HARD FIBROMA, SHOWING DENSE FULLY-FORMED FIBROUS TISSUE, WITH CAPILLARY BLOOD-SPACES LINED BY ENDOTHELIUM. (× 300.)

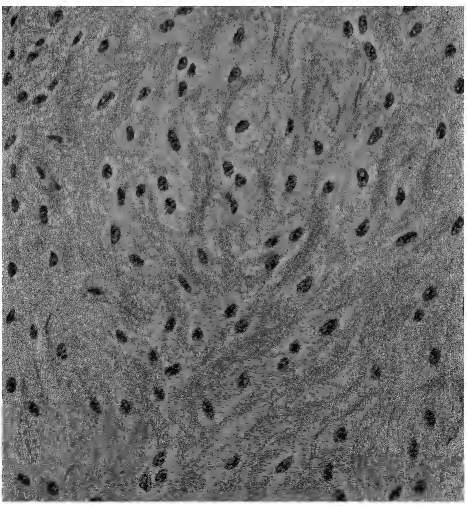


FIG. 48.—SOFT FIBROMA, SHOWING LESS FULLY-FORMED FIBROUS TISSUE THAN IN THE HARD FIBROMA OF FIG. 47 ABOVE. (× 300.)

and freely movable; but, if exposed to pressure or friction, as when situated on a man's shoulder (Fig. 50) and rubbed by the braces, it may become firmly adherent to surrounding structures. Such growths are either single or multiple, in the latter case perhaps occurring in hundreds, and are most commonly found about the trunk or the upper extremities. Occasionally subcutaneous tumours become pedunculated and pendulous, especially about the upper part of the thigh.

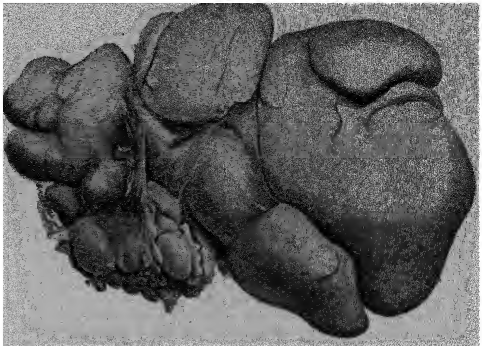


FIG. 49.—LIPOMA, SHOWING CHARACTERISTIC LOBULATED OUTLINE. (FROM KING'S COLLEGE HOSPITAL MUSEUM.)

The diagnosis of a subcutaneous lipoma from a chronic abscess is made by noting that in the former there is a defined outline of a lobulated character, that the edge slips away on making pressure over it, and that the skin dimples on moving the growth from side to side. In a chronic abscess the swelling is less defined in outline, has a shelving margin, and the skin is either quite free or adherent over a considerable area. Fluctuation is present in both, since fat at the temperature of the body is fluid.

FIG. 50.—LIPOMA OF SHOULDER.

Deep intermuscular lipomata occur, and the diagnosis is often difficult, since their mobility and lobulated outline are masked by the superjacent tissues; they have even been mistaken for sarcomatous growths. Still more difficult of recognition are those known as **Parosteal Lipomata,** growing from the outer surfaces of the periosteum. They are often congenital, and appear as soft swellings, lying beneath the muscles in close proximity to a bone, and suggesting the presence of a chronic abscess. Lipomata arising from the fatty tissue of the synovial membrane may develop in and around **joints.**

A **painful lipoma of the foot** has been described as occurring on the inner side of the sole, causing great pain on walking and simulating flat-foot. Removal by operation is necessary, and must be very thorough, if recurrence is to be avoided.

Pericranial Lipoma is of a somewhat similar nature. It is usually congenital in origin, and the cranium may be hollowed out beneath it. An angiomatous element is sometimes present in these growths (nævo-lipoma).

Localized overgrowths are often met with in the subperitoneal fatty tissue, constituting **Subserous Lipomata.** They occur not infrequently in the lower part of the abdomen, and may extend into the inguinal and crural canals. By their traction a process of peritoneum may eventually be drawn down, and a true hernia produced. A similar condition occurs in the anterior abdominal wall, small pedunculated masses of fat projecting through congenital or acquired openings in the linea alba or linea semilunaris; these are known as **Fatty Hernia of the Linea Alba,** and are often painful.

Occasionally the connective-tissue basis of a lipoma undergoes modifications—*e.g.*, it may become increased in amount and fibrous in character, it may be associated with a myxomatous element, or even become sarcomatous. For nævo-lipoma, see p. 395.

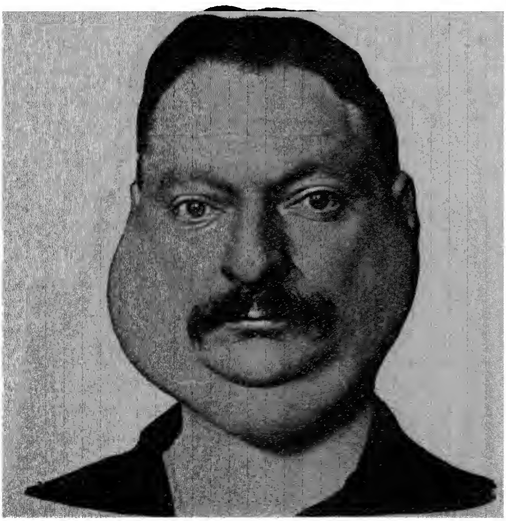


FIG. 51.—DIFFUSE LIPOMA.

By the term '**Diffuse Lipoma**' or Lipomatosis (Fig. 51) is meant a fatty infiltration, rather than a true fatty tumour, of the subcutaneous tissues of some region of the body, particularly beneath the chin and at the back of the neck, and more rarely in the pubic region. These masses are often multiple and almost always symmetrical. They usually occur in men who drink beer freely and take but little exercise. Their size sometimes diminishes on limiting the amount of alcohol and making the patient do physical work.

In some of these cases the term ' diffuse ' is not strictly merited, as the growths are in reality limited, but the limitations are difficult to define in the midst of the surrounding fat. They have a considerable tendency to burrow, and by their pressure on important organs may sometimes lead to serious symptoms.

The **Treatment** of lipomata consists in their removal. When they are loosely encapsuled, this is a very simple matter, all that is required in many cases being to squeeze the mass forwards between the thumb and finger, making the skin tense over it, and then to incise the capsule freely, when the tumour almost is extruded; but if there are many adhesions it may not be so easy.

Chondroma.—Cartilaginous tumours grow in connection with either bone or cartilage. They consist of hyaline cartilage, which, instead of being uniform in texture and devoid of vessels, as at the articular ends of bones, occurs in the form of islets or nodules of varying size, held together by vascular connective tissue, which may even penetrate into its substance. The cells are also less regular in shape than is the case with normal cartilage, and are not arranged according to any definite plan.

Chondromata are liable to become calcified, and even ossified. When large, the central parts may undergo a mucoid change, giving rise to a cavity which, if infection is admitted, becomes exceedingly foul. They are not uncommonly complicated in their growth bv sarcomatous and other elements.

Chondromata of the smaller bones are not infrequent, being seen usually in the hands of young people, and are often multiple (Fig. 52). The growth commences in the interior, close to the epiphyseal cartilage, and results in expansion of the bone, the hand becoming thereby deformed. Treatment consists in incising the capsule, and scooping out the cartilaginous tissue, a proceeding which may result in defective growth and subsequent deformity. In the later stages amputation is inevitable.

Fig. 52.—Multiple Chondromata of the Fingers.

When growing from the long bones, chondromata usually start from beneath the periosteum, and are independent of the epiphyseal cartilage, although it was suggested by Virchow that they originate from a nodule of cartilage displaced from its usual situation during an attack of rickets. They constitute firm, lobulated, encapsuled tumours, and give rise to no pain, except when they encroach on neighbouring nerves owing to their size. The growth may extend secondarily into the medullary canal of the bone, and thus cause its expansion; or it may erode the compact tissue, and lead to so-called 'spontaneous' fracture. Amputation of the limb will probably be necessary, unless the case comes under observation in the early stages, when the tumour can be gouged or scraped away. Radium treatment has been proved to be of no value.

Overgrowths of cartilage, known as **Ecchondroses,** may occur around the articular cartilages in connection with osteo-arthritis; they also arise from the cartilages of the ribs, or nose, larynx, etc. Some of the loose bodies which form in joints are of a similar nature. These, though probably not originally neoplastic in nature, may become so.

Chordoma.—This is a rare form of tumour developing from remnants of the notochord, and may be found growing from the basi-sphenoid or basi-occipital bones, or from the vertebral column, especially at its lower end.

Osteoma.—Bony tumours are of two chief forms: the cancellous and the ivory.

Cancellous Osteomata are usually met with growing near the articular end of a bone, being derived originally from some isolated

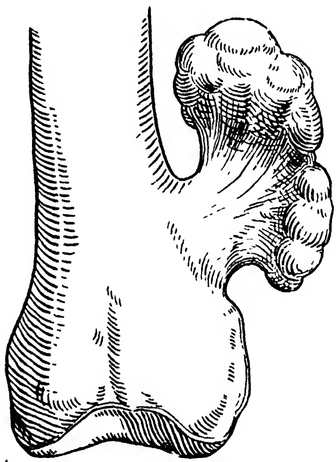


Fig. 53.—Cancellous Osteoma of Lower End of Femur (Semi-diagrammatic, from a Radiograph).

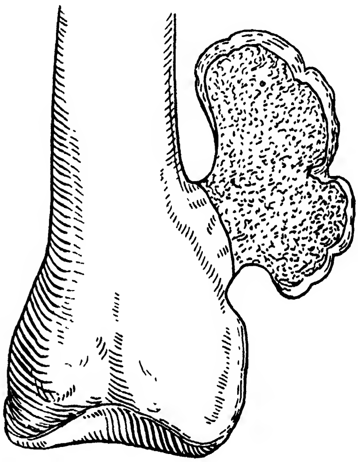


Fig. 54.—The Same, with Osteoma divided Longitudinally to show the Extent of the Investing Cartilage.

portion of the epiphyseal cartilage, which has perhaps been separated from its original connection after an attack of rickets. If such an island is placed near the periphery of the bone, it is easy to understand its development into a tumour, which consists of cancellous bone, capped by a layer of hyaline cartilage, from which it grows (Figs. 53 and 54). It is pedunculated or sessile, and may attain to a large size, leading to considerable deformity. It develops in young people, and may be congenital. As the individual grows, the basis of attachment may become separated from the epiphysis to an extent corresponding to the amount of growth which has taken place at that spot, or it may still remain attached to the diaphysis close to the epiphyseal line. As a rule its growth and development cease

at maturity, when the cartilage covering it, as well as the epiphyseal cartilage, ossifies. A bursa occasionally forms over the most prominent part of these tumours as a result of friction or pressure, giving rise to the condition known as exostosis bursata; this cavity may communicate with the joint. An effusion of blood or serum into the bursa may be the first evidence of the existence of such a growth. Multiple exostoses (by Keith and others regarded as *not* neoplastic in nature) are not infrequently met with, and are then often congenital. The commonest situation for such a growth is the inner condyle of the femur, close to the adductor tubercle, and it may cause discomfort, especially in riding. The upper end of the tibia is sometimes affected, and, when the growth develops on the inner side, trouble may arise from hitching of the tendons there inserted over the neck of the growth, causing painful locking of the knee. The subungual exostosis (Fig. 55) develops as a rounded, cherry-like swelling under the nail, especially that of the great toe. It is very painful, and should be treated by removing the nail, incising the tissues over it down to the bone, and cutting it away with pliers or gouge.

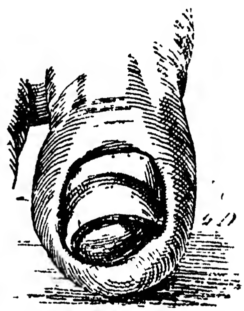


FIG. 55.—SUBUNGUAL EXOSTOSIS.

Ivory Exostoses develop most frequently on the inner or outer aspect of the cranial bones, affecting especially the orbit, external auditory meatus, antrum, and frontal sinus (Fig. 56). They consist of masses of very dense compact tissue, covered by periosteum, from which they grow. They are usually lobulated, and, when situated in the frontal sinus, or growing from the under surface of the skull, may give rise to serious symptoms from irritation or compression of the brain or its membranes. In a few cases necrosis has resulted, and they have sloughed out, thus bringing about a spontaneous cure.

Occasionally diffuse overgrowths of the bones of the skull (**Hyperostoses**) are met with, affecting either the calvarium alone, being then probably syphilitic in nature, or the facial and cranial bones, as in leontiasis ossea. New formation of bone, probably inflammatory in origin, also occurs in the substance of muscles and tendons which are exposed to irritation or excessive action—*e.g.*, the tendon of the adductor longus in riders, producing what is known as 'the rider's bone' (Chapter XVIII.).

The **Treatment** of osteomata consists in their removal when necessary. This may be simple in the case of the cancellous osteomata of the limbs, but is sometimes a formidable proceeding when dealing with compact exostoses of the calvarium. The fact that cancellous osteomata cease to grow when the patient reaches maturity explains the rule of surgery that they do not need to be removed unless causing pain or mechanical inconvenience by their

size. The tumour is chiselled or sawn away from its attachment to the bone, special attention being directed to the total removal of the covering cartilage, since growth continues unless this is completely excised.

Compact osteomata of the cranium may be separated and removed by chiselling away the bone around them, but occasionally a burr driven by electricity is required in order to divide their attachments; they should not, however, be touched unless causing obvious symptoms.

Odontoma.*—Tumours originating from some abnormal condition of the teeth or teeth-germs are known as 'odontomes.' Bland-Sutton, in his work on tumours,† has described seven different

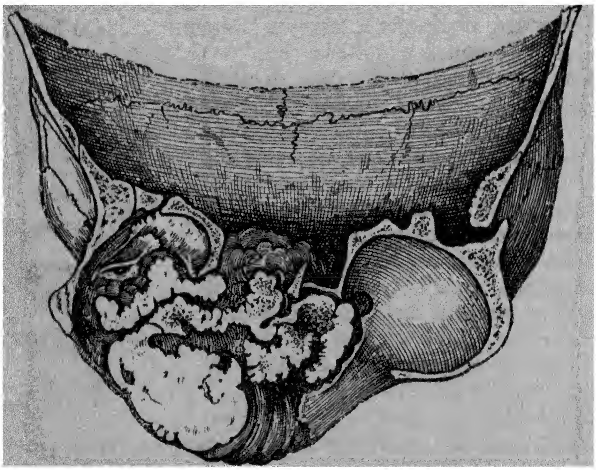


FIG. 56.—IVORY EXOSTOSIS GROWING FROM FRONTAL SINUS, AND ENCROACHING ON BOTH THE ORBIT AND THE CRANIAL CAVITY.
(From specimen in the College of Surgeons' Museum.)

varieties, several of which are, however, rarely met with in man The more important of these are as follows: (1) **Epithelial Odontome.** In this condition, also known as 'fibro-cystic disease of the jaw,' the mandible is most commonly affected. A tumour forms, consisting of spaces lined by epithelium, which are developed as irregular outgrowths from the enamel organ. It occurs most frequently in young adults, and may grow to an enormous size. (2) **Follicular Odontomes,** or, as they are often termed, 'dentigerous cysts,' are produced by the development of a cavity around a misplaced or ill-developed tooth of the permanent set, which often

* For a full description of the odontomata see Wakeley and Buxton, Textbook of Surgical Pathology,' 1929, John Wright and Sons, Bristol.

† Bland-Sutton, 'Tumours, Innocent and Malignant,' 6th edition, Cassell and Co., London, 1917, p. 231.

lies horizontally, so that its eruption is impossible. (3) **Fibrous Odontomes** are the result of a thickening and condensation of the connective tissue around a tooth-sac. They are most frequently observed in the lower animals, but are also said to occur in rickety children. (4) **Compound Radicular Odontome** is the term applied to a tumour composed of cement and dentine, developing at the root of a tooth. It gives rise to severe pain, and may cause suppuration in the surrounding bone. (5) **Composite Odontomata** consist of a conglomeration of the various forms of tissue entering into the formation of a tooth, and developing in the neighbourhood of the jaw. They may be very large, and probably some of the bony tumours described as osteomata of the antrum are of this nature. (See also Chapter XXVIII).

Myeloma.—This tumour, which was formerly described as a myeloid sarcoma, is in reality derived from the bone-marrow, and

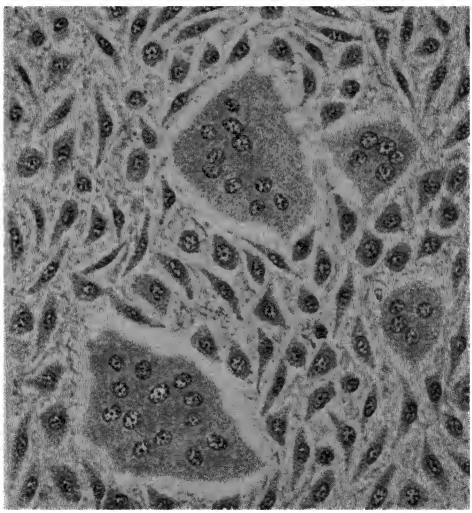


FIG. 57—'BENIGN MYELOMA' OF BONE, SHOWING THE LARGE MULTINUCLEATED GIANT-CELLS OR MYELOPLAXES, LYING AMONGST THE MORE ABUNDANT SPINDLE-SHAPED AND IRREGULAR CELLS (× 300.)

is usually comparatively 'benign' in its nature. It is characterized by the presence of large numbers of multinucleated giant-cells (myeloplaxes), embedded in a groundwork of round or spindle cells, the intercellular substance being usually of a gelatinous nature (Fig. 57). The myeloid cells vary in size, but always contain many nuclei, which are not distributed regularly in the periphery of the cell, as in the giant-cells of tubercle; they may be regular in outline, or prolonged into numerous interlacing processes, although these

latter are usually not very evident. There is also no definite arrangement of cells around them, as in the tuberculous giant-cell systems. These tumours are soft in consistency, and on scraping a slimy fluid is obtained. They are very vascular, and may pulsate. Hæmorrhage into their substance is common, giving rise to cysts, filled with serum and a yellowish fibrinous clot. When fresh, the growing edge is of a dark maroon colour on section, and has been likened to the appearance of a pomegranate. Though infiltrating locally, they seldom give rise to secondary deposits. Their growth is often tolerably rapid, and they may attain enormous dimensions. For particulars as to their clinical characters, see Chapter XXI., p. 671.

Diffuse Myelomatosis, or myelopathic albumosuria, is a condition in which the marrow of the vertebræ, sternum, and ribs, and occasionally of the long bones, is transformed into a structure closely resembling that of the myelomata. The bony tissue is absorbed, and deformity or spontaneous fracture may result. It is associated with the presence in the urine of albumose, which is precipitated at a comparatively low temperature, and redissolved on boiling.

Myoma.—Myomata are of two varieties, **Leiomyomata** and **Rhabdomyomata,** consisting of unstriped and striped muscle-fibres respectively, the latter being very rare, occurring especially as congenital tumours, *e.g.* in the kidney, heart, etc., especially in conjunction with tuberose sclerosis and adenoma sebaceum in one type of congenital idiocy. Striped muscle may also be found in some teratomatous tumours. The **Leiomyoma,** on the other hand, is one of the commonest of tumours, forming rounded and often encapsuled tumours, the cells of which are long and fusiform, and contain a rod-like nucleus. These cells are grouped together into interlacing bundles and whorls, with a varying admixture of fibrous tissue. The tumours themselves are not very vascular, but vessels of considerable size are often found in the capsule.

Myomata frequently occur in the uterus, occasionally in the prostate, and more rarely in the walls of the alimentary canal or in the ovary. All intermediate admixtures of myoma and fibroma are found—fibro-myoma—and also of myoma and glandular elements in the form of adeno-myoma. Secondary changes sometimes develop in myomata—*e.g.*, mucoid softening, necrosis, calcification, ulceration with profuse hæmorrhage, and possibly consequent inflammation, whilst sarcomatous metaplasia may occasionally supervene.

Gliomata are tumours arising from the neuroglia of the brain and spinal cord, and occasionally in the retina. Twenty varieties of glia-cells and some fourteen varieties of gliomatous tumours have been described by Bailey and Cushing.* These vary from simple to locally malignant and very actively proliferating cellular tumours. They consist of cells (which may be round, spider-shaped, or spindle-shaped) and of fibres; these occur in varying proportions in different cases, giving rise to the harder and softer varieties. Their colour often

* 'Tumours of the Glioma Group,' 1926.

closely resembles that of the brain itself, and there may be no sharp line of distinction between the tumour and the surrounding tissue. They vary greatly in rapidity of growth and in vascularity, and, though often locally malignant and infiltrating widely, seldom give rise to metastases.

Neuroma.—**True Neuroma, Neuroblastoma,** or **Ganglio-neuroma** is rare, comparatively few undoubted cases being on record. It consists of a mass of newly-formed ganglion-cells and nerve-fibres, which may be medulated or not. It affects especially children or young people, and usually involves the sympathetic system or the suprarenal medulla. The tumours may attain considerable dimensions, are often multiple, and may be soft or firm. They are insensitive and innocent, and may be freely removed if necessary.

False Neuromata, or **Neuro-fibromata,** developing in connection with the sheaths of nerves, are in reality fibromatous tumours, but may for convenience be described here under three headings:

1. **Localized Pseudo-Neuroma,** which may be innocent or malignant, the former being a fibroma or myxoma, the latter usually a sarcoma. It may project from one side of the nerve, but more frequently the nerve-fibres are spread out over it. It may be moved more freely at right-angles to the axis of the nerve than along its course. When developing from a small subcutaneous twig, it is termed a 'painful subcutaneous nodule,' and gives rise to intense radiating neuralgic pain, especially when compressed or irritated, or when exposed to cold. A false neuroma growing from a larger mixed nerve ('trunk-neuroma') is less painful, because there are relatively fewer nerve fibrillæ, and the mass is less exposed. One important site of such neuro-fibromata is the eighth or acoustic nerve, at the cerebello-pontine angle. A growth on a pure motor nerve, though sensitive, is not associated with radiation of pain. It is uncommon for tumours of this type to cause complete paralysis or anæsthesia, unless they are of a malignant nature. They occur most frequently in healthy adults, and in women a little more commonly than in men.

Treatment.—The tumour, if painful, should be removed, care being taken, if possible, not to interfere with the continuity of the nerve-fibrillæ, the dissection of the sheath being made in the long axis. If this cannot be accomplished, the nerve must be divided, the growth removed, and if possible the ends subsequently sutured together. In removing a painful subcutaneous nodule upon an unimportant sensory twig, it is unnecessary to endeavour to save the nerve.

The malignant pseudo-neuroma, as already stated, is sarcomatous in character, and develops at first in the sheath of the nerve, spreading longitudinally, but subsequently involves the tissues around. Clinically, it presents at first the phenomena of a simple growth, but its course is more rapid and painful, and if involving a motor nerve paralysis is induced. The main nerve-trunks are usually affected, and it may be possible to treat the case by excision or, failing this, by amputation.

2. **Generalized Neuro-Fibromatosis.**—This consists of nodular thickenings of the nerve-sheaths, causing multiple spindle-shaped or spherical tumours, or a generalized enlargement. The growths may be encapsuled and limited, or not; they may be few in number, or hundreds may be present, and they are usually whitish and firm in texture. They originate from the endoneurium of the primary nerve-bundles. Any part of the peripheral nervous system may be affected, including the sympathetics, but the disease is most common in connection with the cranial nerves and the large plexuses of the trunk. The actual symptoms are sometimes very slight, but the tumours may be sensitive to pressure, and some of them, more

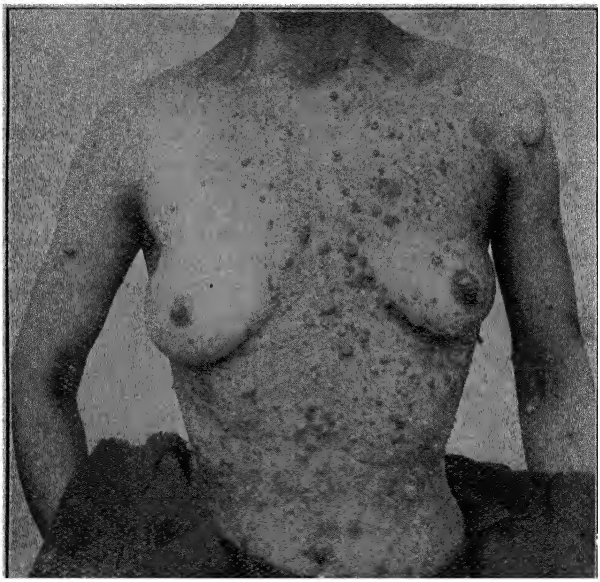


Fig. 58.—Multiple Molluscous Tumours and Pigmentation of Skin in a Case of Recklinghausen's Disease.

exposed than the others, may be exquisitely tender. Motor phenomena are rare, and paralysis is usually due to involvement of the nerve-roots in the spinal canal, or to the supervention of sarcoma, which is a not uncommon termination. The disease may start at any time during life, and, although progressing slowly, sooner or later terminates fatally. No known treatment is of any avail, but should any particular tumour become large and tender, it may be removed.

A **Plexiform Neuro-fibroma** is a special modification of this process, occurring congenitally or in young people, and usually involving the trigeminal or superficial cervical nerves; it may be associated with

the above condition. The overgrowth is of a softer, more gelatinous, myxo-fibromatous type, and the resulting tumour consists of a plexus of thickened, tortuous strands, of soft consistence, held together by loose connective tissue, but easily separable into their constituent elements, which are of a nodulated character, so that the dissected mass looks 'not unlike grains of boiled tapioca on a string' (Alexis Thomson). The plexiform neuroma is usually subcutaneous, but may dip deeply between and into the substance of muscles. When limited in extent, the growth may be dissected out, and this is usually required for cosmetic purposes. The final prognosis is rather better than in the generalized form, as secondary sarcomatous changes are rare.

In this affection one not infrequently observes a large development of fibrous growths of the skin, similar to what we have already described as molluscum fibrosum. On careful microscopical examination of specimens stained by Weigert's method, the presence of nerve-fibrillæ may be demonstrated in these growths, showing that they are really neuro-fibromatous in origin. So excessive does this overgrowth occasionally become that a form of elephantiasis is produced—*e.g.*, the irregular hyperplasia of the scalp-tissues—known as a pachydermatocele. The association of molluscous tumours with neuro-fibromatous changes in the nerves and cutaneous pigmentation constitutes the affection known as *v.* Recklinghausen's disease (Fig. 58).

3. The bulb formed upon the end of the proximal segment of a nerve after its division is sometimes rather inaccurately termed a 'neuroma' (**Traumatic** or **amputation 'Neuroma'**). It consists of a mass of fibro-cicatricial tissue containing spaces, within which are numbers of newly-formed axis-cylinders (Fig. 125).

(2) Malignant or Atypical Pulp-tumours ('Sarcomata').

Sarcoma (=a flesh-like tumour; Greek, σαρξ, flesh).—A sarcoma is a malignant tumour which consists of a parenchyma, formed of cells which have taken on the power of continued and apparently limitless growth, and of a varying amount of more or less inert supporting network or stroma. It is characteristic of the sarcomata that these two elements are intimately mingled together, each parenchyma-cell being separated from its neighbours by delicate fibrillæ of the stroma; in the carcinomata the parenchyma cells tend to occur in masses or alveoli which are enclosed by the stroma. Sarcomata have in the past usually been regarded as being of **mesoblastic** origin only, the parenchyma-cells resembling those from which the connective tissues are formed in the embryo both in shape and in their capacity for continued growth; hence they are often referred to as 'embryonic connective-tissue cells.' Analogous malignant tumours may, however, arise from the pulp-tissues derived from **epiblast** (neuroglia in all its varieties) and **hypoblast** (the notochord and its remnants); and also, by reversion, from the **meso-** and **endo-thelial** derivatives of the mesoblast. The difficulties frequently encountered in the older

classifications have been scientifically overcome by Adami's method of classifying all of these as malignant 'pulp-tumours' (sub-grouping them, when necessary, as epi-, meso-, or hypo-hylomata or pulp-tumours respectively). Inflammatory new formations are also composed of mesoblastic cells which have assumed the power of growth, and in both cases these 'embryonic' cells may undergo organization into more mature forms of connective tissue, such as fibrous tissue or bone. There is, however, this marked difference between the two: the inflammatory new formations arise as the result of a definite irritant, and cease to spread when that irritant ceases to act; whereas the sarcomata arise without any as yet discovered cause, and continue to spread indefinitely.

A sarcoma may at first be well defined or even encapsulated; but many forms from the first, and all later on, infiltrate the surrounding tissues, replacing them with their own particular structure, a process which can be well observed in sarcomata of muscles. The **blood-supply** is very abundant, and, indeed, may be so free as to cause the tumour to pulsate. The vessels consist of spaces or clefts within the tumour substance, and are lined by the most delicate endothelium or even merely by the tumour-cells; the arteries and veins in the neighbourhood are much dilated. Interstitial hæmorrhage is frequent, owing to the imperfect nature of the vessel-walls, and pseudo-cystic cavities may in this way be produced. **Dissemination** is usually dependent on the relation of the tumour to the veins. As already stated, the veins communicate with spaces hollowed out of the tumour substance; into and along these the sarcomatous tissue may burrow, until the apex of this intravascular growth projects into the lumen of a vessel in which the blood is freely circulating. It may be detached by some slight mechanical injury, and is then carried away as a malignant embolus; if a large portion is set free, as in sarcoma of the kidney, it may lodge in the right side of the heart, or in the lungs, and cause a fatal result. Smaller emboli are either detained in the lungs, or pass through into the general circulation, giving rise to secondary growths wherever they are arrested; general visceral implication is often secondary to the pulmonary growths. Occasionally dissemination by way of the lymphatic glands occurs, especially in a lympho-sarcoma and sarcomata of the tonsil, testis, and thyroid body, and this in spite of the fact that lymphatics are not known to be present in sarcomata.

The various forms of sarcoma described below have a tendency to become organized, usually only very imperfectly, into tissues which bear a close resemblance to the normal connective tissues, and tumours in which this process has taken place often receive special names—*e.g.*, fibro-sarcoma, in which the parenchyma cells become organized into fibrous tissue; osteo-sarcoma, in which they develop into bone; chondro-sarcoma; and lipo-sarcoma. The secondary deposits usually resemble closely the parent tumour; thus masses of osteoid tissue may develop in the lungs when the primary growth is an osteo-sarcoma.

Degenerative changes of a fatty or mucoid type and necrosis are also apt to occur in the older portions of a sarcoma, giving rise to the production of pseudo-cystic cavities, but the malignancy of the tumour is not thereby affected. Hæmorrhage is common in the softer varieties, and calcification is not infrequent in the more chronic forms.

On naked-eye examination, a sarcoma presents a more or less homogeneous appearance, the colour varying with the amount of the blood-supply, from a grayish-white in the fibro-sarcoma to a deep red in the small round-celled. Its consistency, whether hard or soft,

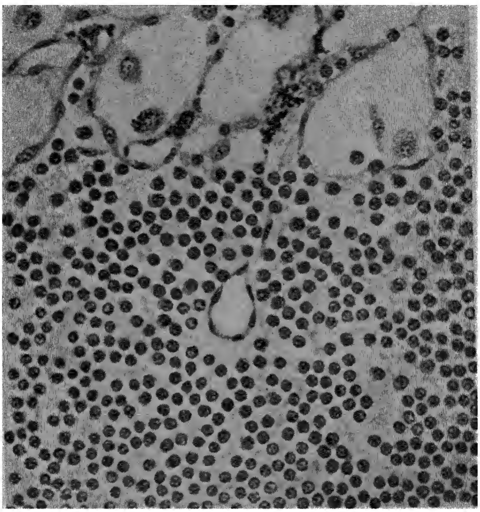


FIG. 59.—LYMPHOSARCOMA, SECONDARY IN LUNG, SHOWING ACTIVE INVASION AND REPLACEMENT OF THE LUNG-TISSUE, SOME SURVIVING ALVEOLI (WITH CARBON PIGMENT IN THEIR WALLS) BEING SHOWN AT THE UPPER PART. (× 300.)

depends on the amount of stroma present; the more malignant are usually soft and may pulsate visibly; the more chronic are often firmer.

Sarcomata may occur at any age, and are perhaps commonest in young and middle-aged people, especially affecting the first and fourth decades of life; they may also be congenital. The degree of malignancy varies considerably, some forms being almost 'benign,' or, at any rate, infiltrating only locally, whilst others are exceedingly malignant in nature.

Sarcomata are, for convenience, divided into the following groups, depending on the size, shape, arrangement, and character of the constituent cells:

(*a*) **Round-celled Sarcomata** (Fig. 60) usually consist of a mass of **small round cells,** each containing a very definite circular or oval nucleus; the intercellular substance is scanty, and often homogeneous in character. The mass is very vascular, and may even pulsate; it is soft, like granulation tissue, and usually grows rapidly. It is extremely malignant, infiltrating surrounding parts, and early giving rise to secondary deposits; lymphatic glands are not infrequently affected in this variety. The small size of the cells is thought to be an indication of the rapidity of development, since they divide before attaining to a large size. Any part of the body may be involved, and this variety of tumour may occur at any age. **Lympho-sarcoma** is a variety of this type (Fig. 59), in which the intercellular substance is scanty and of a delicate reticular nature, corresponding to

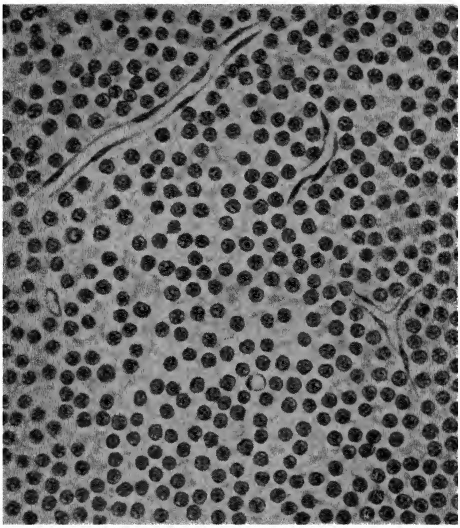


FIG. 60.—SMALL ROUND-CELLED SARCOMA, SHOWING GREAT CELLULARITY OF THE TUMOUR, AND IMPERFECT STRUCTURE OF THE VESSELS. (× 300.)

the retiform tissue occurring in lymphatic glands. It grows rapidly, and is exceedingly malignant; it usually starts in lymphatic glands, the thymus, or in the lymphoid tissue of mucous membranes, and is disseminated by means of the lymphatics. For the clinical characters of lympho-sarcomata, see Chapter XV.

The **large round-celled** sarcoma is an uncommon variety made up of larger cells, which contain one or more large oval nuclei with an abundant protoplasm around. A well-marked stroma is interspersed between the cells, and an alveolar arrangement is sometimes present; it occurs in the same positions as the small-celled variety, but is rather less malignant.

(*b*) **Spindle-celled Sarcomata** (Fig. 61) consist of large or small spindle cells, which are often arranged in a somewhat fasciculated manner with a greater or less amount of intercellular substance.

When consisting of **small cells,** the tumour grows rapidly, and is firmer and less succulent than the round-celled variety. They may originate in any part of the body, but more especially from aponeuroses, fasciæ, tendons, etc., constituting localized growths, which are at first tolerably well defined, but later on invade and infiltrate surrounding parts. When growing rapidly, the cells become less fusiform in shape, and may even approach to the round cell in character, after passing through a stage known as the oval or **oat-shaped** sarcoma. A few giant-cells are often seen in these

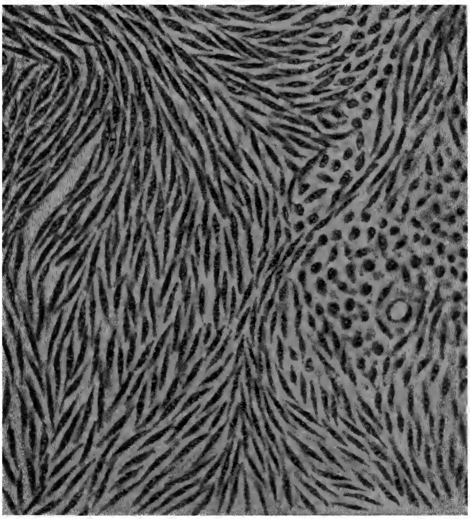


FIG. 61.—SMALL SPINDLE-CELLED SARCOMA

Some of the fibres run in longitudinal bundles; others are cut transversely. Inter-cellular material is scanty and the vessels imperfect. (× 300.)

cases. These tumours, consisting of small spindle-cells, are usually very malignant.

In some few cases the cells undergo organization into rather more fully-formed fibrous tissue, and the tumour closely resembles a simple fibroma, being well defined. These tumours are known as **fibro-sarcomata** ('recurrent fibroid' tumours of Paget), and are not uncommon in the subcutaneous tissues (see Fig. 62). They are on the border-line of malignancy, since they rarely form secondary growths, and often do not return for two or three years after removal. After each operation, however, they usually recur more rapidly; and show signs of

greater malignancy, until, after perhaps being removed a dozen times, they recur with all the characters of an ordinary spindle-celled sarcoma.

The **large spindle-celled** sarcomata are softer and of a deeper colour than the above forms. They grow from the fibrous tissues, and not uncommonly from the viscera.

(*c*) **Mixed-celled Sarcomata** are of not infrequent occurrence, varying admixtures of two or more of the above types being present in the same tumour.

The **Treatment** of sarcoma consists in its **removal,** if practicable, as early and completely as possible. Even in cases where the

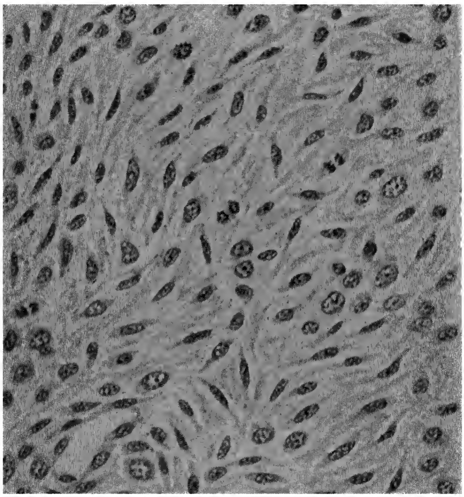


FIG. 62.—FIBRO-SARCOMA—THE SO-CALLED 'RECURRENT FIBROID.'
The specimen from which this preparation was made was the third 'recurrence' after operation. In histological structure it is intermediate between the soft fibroma (Fig. 48) and the spindle-celled sarcoma (Fig. 61). (× 300.)

tumour is apparently encapsuled, recurrence is very likely to follow unless the capsule is also taken away, and a considerable margin of tissue beyond it. Where the growth is more diffuse, the only hope lies in cutting widely, so as to get beyond its furthest limits, and it may be advisable to remove the skin over it and the lymphatic area leading from it; the prognosis of such cases is very bad.

In cases where, owing to the position of the growth or its extent, complete removal is impossible, a partial operation may be feasible, cutting away part of the tumour with a diathermic cautery, and trusting to **radio-therapy** (p. 319) to destroy the remainder, employ-

ing either X-rays or radium. In the former case one or two pastille doses over different areas are given twice a week at a sitting. In the latter small doses of radium may be buried in the tumour substance for six to eight days. Lead therapy, combined with irradiation, is still in its experimental stage.

In hopelessly **inoperable** cases analogous measures have been employed as for the similar stage of cancer (*vide* p. 244). Many cures have been recorded from the use of Coley's fluid, which consists of a sterilized culture of the *Streptococcus pyogenes* of erysipelas and *Bacillus prodigiosus* in bouillon. This fluid is intensely toxic, and the injections, commencing with doses of half a minim, are gradually increased up to 7 or 8 minims or more; severe reaction usually follows, and the surgeon should aim at obtaining two or three such effects each week. The fluid is introduced partly into the abdominal wall, and partly into or around the tumour. If it is going to do any good, the improvement is manifest in a few days, and as the course of treatment proceeds the growth gradually dwindles. The patient is treated for three or four weeks at a time, and then given a rest, as the repeated reactions are very trying, and to persist in this treatment requires much pluck and patience. The results obtained in this country hitherto have been very disappointing.

Melanomata are pigmented tumours, of which the **simple** types are represented by the congenital pigmented nævi or moles and warts of the skin. From these, and also from those portions of the body which are naturally pigmented, *e.g.* the uveal tract of the eye (choroid, iris, and sheath of the optic nerve, etc.), and occasionally from the meninges, **malignant melanomata** may arise. The exact origin, epithelial or mesoblastic, of the chromatophores or pigmented cells of these tumours has been much debated,* and need not be fully discussed here. They constitute perhaps the most malignant type of neoplasm on account of their tendency to give rise at an early stage to metastases in any tissue or organ of the body. Those growing from the eye are usually composed of spindle-cells, which contain granules of melanin; these choroidal tumours have a special tendency to form secondary deposits in the liver. The melanomata of the skin may have an alveolar structure, and were formerly regarded as alveolar sarcomata, but some pathologists regard the tumour-cells as being derived from downgrowths of the surface epithelium, and classify the tumours themselves as carcinomata. The pigment-granules in this form are very unevenly distributed, some lying in the stroma between the alveoli, whilst others are contained in the cells (see Fig. 63); some portions of the primary tumour are often free from pigment, and some of the secondary growths are colourless, whilst adjacent growths may be absolutely black. Apart from the tumours, the melanin

* See, for example, Ewing's 'Neoplastic Diseases,' W. B. Saunders and Co., Philadelphia and London, 3rd edition, 1928, p. 919 *et seq.*

pigment may be deposited in the skin of the patient (melanosis), or may be excreted in the urine (melanuria).

If the primary tumour is not removed very early, the nearest lymphatic glands are soon affected, and secondary metastases follow. The original tumour is often not very large, and the secondary deposits are frequently characterized by their number

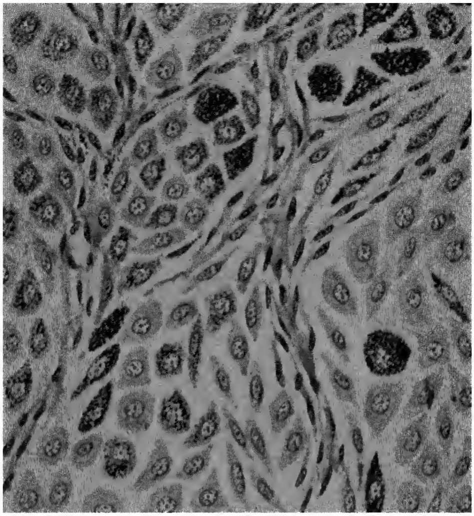


FIG. 63.—MALIGNANT MELANOMA, SHOWING THE ACTIVELY GROWING SPINDLE-SHAPED AND IRREGULAR CELLS, AND THE OFTEN PATCHY DISTRIBUTION OF THE MELANIN-PIGMENT.

This tumour was a secondary growth arising from a pigmented mole on the skin. (× 300.)

rather than by their size, perhaps scarcely an organ or tissue in the body escaping attack.

Of late years a more benign type of cutaneous melanosis has been described, and is now well recognized by dermatologists. It usually spreads from a congenital mole as a deeply pigmented patch, which may extend over an area of several square inches, and presents at first no sign of induration or infiltration. In this stage microscopical examination reveals no change in texture except pigmentation of the deeper layers of the cutis vera. Sooner or later, a tumour develops in the centre of this patch; it is not very rapid in its course, but if left alone will finally become disseminated In treating this type of melanosis, it is essential to remove every portion of pigmented tissue as well as the tumour.

II. Rind-Tumours derived from Covering and Lining Tissues.

(1) Simple or Typical.

The various tumours grouped under this heading are composed mainly of epithelium or other covering or lining cells, combined with a variable admixture of connective tissue. They are derived from pre-existing epithelial or other analogous structures, and vary in the arrangement and character of the cells with the site of origin. For convenience of description, we may take first the simple tumours arising from epithelial tissues, the papilloma and adenoma.

Papilloma.—It is convenient to classify the papillomata according to the nature of the epithelium with which they are covered.

(1) Those covered by **squamous** epithelium occur in the skin, lips and mouth, larynx, vagina, anus, etc., and consist of projecting papillæ, undergoing proliferation and frequently branching to form secondary papillæ. If the epithelium undergoes keratinization, as

FIG. 64.—SECTION OF A WARTY PAPILLOMA TO SHOW THE ARRANGEMENT OF THE EPITHELIUM.

The normal skin is seen on each side running into the hypertrophied papillæ, over which is heaped up a mass of thickened keratinized cuticle. There is no invasion of the subcutaneous tissues, as in an epithelioma.

in common warts, the latter become hard, and may constitute horn-like outgrowths (Fig. 64). When such outgrowths occur in moist situations—*e.g.*, between the toes, on the prepuce, or growing from mucous membranes (except that covering the vocal cords)—this formation of horny substance is usually very imperfect, and the papillomata remain soft. It must be pointed out that many such warty outgrowths are of infective origin, and not true tumours—*e.g.*, venereal warts, condylomata, and mucous patches. There are also reasons for suspecting that the common cutaneous wart may be infective and due to a micro-organism. Not infrequently a papilloma which has become irritated may undergo malignant change and be transformed into an epithelioma, a change which would be characterized clinically by the base becoming infiltrated.

The papillomata which develop in the bladder and pelvis of the

kidney are covered by many-layered **transitional** epithelium, and usually form long, slender, fimbriated tufts containing delicate bloodvessels, which readily give way and may lead to considerable hæmorrhage. Not infrequently they occur as growths which are or may become malignant.

(2) Papillomata covered by **cuboidal** or **spheroidal** epithelium occur in glandular structures, especially in the breast, kidney, etc.

(3) Papillomata covered by **columnar** epithelium are sometimes found projecting into cystic cavities in other tumours, as in the proliferous ovarian cysts and in duct carcinoma of the breast, as also into dilatations of other ducts. The 'papillomata' of the intestine are usually either adenomata or fibromata.

Adenomata consist of new growths arising in connection with secreting glands, and in structure simulating somewhat closely the

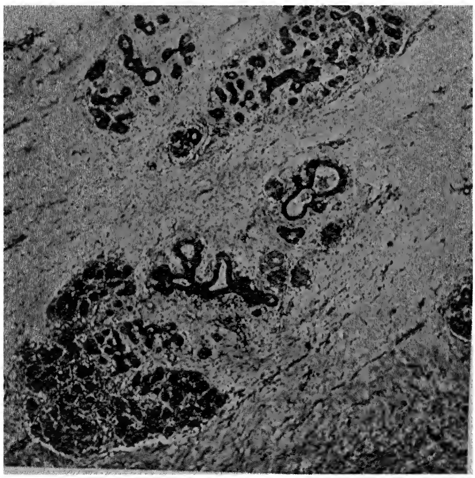


FIG. 65.—HARD FIBRO-ADENOMA OF THE BREAST. (× 30.)

organs from which they arise (Fig. 65). They differ from them, however, in that they do not produce the normal secretion, the alveoli being less perfectly developed, and frequently occupied by several layers of epithelial cells. The epithelium, whether spheroidal, cuboidal, or columnar in shape, does not pass beyond the basement-membrane into the connective tissue, and by this lack of infiltration such simple adenomata are distinguished from cancerous tumours. A variable amount of connective tissue is always present, and may be normal in texture, or may manifest various modifications. Adenomata are single or multiple, and usually encapsuled, and may perhaps be connected with the original gland merely by a pedicle, through which the vessels enter. When growing from mucous membranes, they sometimes become pedunculated, as in the so-called rectal

polypus. The alveoli in some cases become distended with effusion, giving rise to a cystadenoma, and sometimes portions of the tumour project into these, constituting an intracystic growth. These tumours are free from malignancy, except that occasionally the connective tissue undergoes a sarcomatous change; or more rarely carcinoma supervenes, especially in the breast. When of large size, they may cause trouble by compression of important structures. Any glandular organs may become affected with adenoma—*e.g.*, the breast, thyroid, prostate, testis, etc. They are also found as congenital tumours in connection with the thyroid, post-anal gut, and possibly the kidney.

Angioma.—A **Hæmangioma** is a tumour of which the essential constituents are bloodvessels or blood-spaces, with their endothelial lining, for a description of which see p. 392. A **Lymphangioma** is the analogous tumour consisting of the corresponding lymphatic structures (see p. 398).

(2) Malignant or Atypical—Cancer or Carcinoma.

The malignant forms of epithelial new growth, known as the 'cancers' or 'carcinomata,' remain to-day the greatest of the unsolved medical problems, as to both their cause and cure. A vast amount of patient and painstaking investigation has been directed to this subject, and a certain amount of new light has been cast upon it recently which should open up new avenues of approach along which valuable discoveries are likely to be made.

Origin and Causes of Cancer.—In a work of this description and size it is impossible to enter at all fully into such a matter as this, and one can give only the briefest outline of the suggestions which have been made in relation to it. It is probable that when the final explanation of the causation of cancer has been reached, the secret underlying the development of the sarcomata will also have been found, and it is impossible to discuss one without the other, since so much of the experimental work overlaps in the two classes.

The first great fact upon which insistence must be laid is that cancer is always primarily a localized disease, and that when it is possible to discover a cause, that cause is always a local one. Illustrations of this have already been given on p. 204, but other illustrations may be mentioned, since they are of importance in the industrial life of the community. Workers in paraffin, petroleum, shale oil, tar, and pitch (except blast-furnace pitch*) are all liable to develop cancer, but only after many years of exposure, and then preceded by the presence of warts, eczema, etc. Patent-fuel factories, in which coal-dust is mixed with some form of tarry preparation, and compressed into briquets, are also likely to show cases of cancer.

Closely akin to these is the X-ray cancer, which develops on the exposed hands of radiographers. The necessity for protection was not known in the earlier days, and hence not a few of the pioneers in this work have suffered the loss of fingers, arms, or even life itself

* J. M. Legge, M.D., *Brit. Med. Journ.*, December 9, 1922.

from this cause. The cancer is preceded by dermatitis, with cracks and sores, and this occurs on the back and not the palm of the hand, and may stop abruptly at the wrist, where the protection of the coat commences; occasionally the top of the front of the chest, and even the chin or the eyelid, has been attacked. Here, too, the existence of a lengthy latent period before the development of cancer has been demonstrated; an exposure to X-rays for five years is a minimum, and that exposure must be regular and repeated, and not merely a single lengthy exposure which might lead to a burn.

A few cases are also known in which the repeated administration of arsenic for psoriasis or other skin-diseases has resulted in the development of cancer. This observation was made first by the late Sir Jonathan Hutchinson, and has been sufficiently confirmed.

In the experimental work which has been undertaken on animals in the endeavour to ascertain the exciting cause, various substances (alcoholic extracts of tars and such-like oils obtained by fractional distillation, etc.) have been applied to epilated areas between the shoulders of mice and rats, and a number of positive results in the development of epitheliomatous tumours have been secured. This, however, merely proves that in a susceptible animal a suitable irritant applied sufficiently often can produce cancer, a fact that has long been recognized; the most interesting point that emerges is that sarcoma has sometimes been produced by the same means as cancer.

The recognition of the primarily local origin of a cancer is of course the fundamental fact upon which has been built up the operative treatment of the disease, the success of which depends to a very large extent upon the early diagnosis of the case. Laboratory tests dealing with the serum of the patient have been from time to time exploited for this purpose, but at present there is no certain means of diagnosis, except the clinical, and, if need be, the microscopical, examination of a portion of the growth removed for the purpose.

The second great fact in the investigation of the cancer-problem is that the condition is widely spread in the animal kingdom, occurring in fishes, amphibians, birds, reptiles, and mammals; and in all these classes its nature is the same, being characterized by the unrestricted growth of epithelium, attacking first some local focus, and thence spreading by lymphatic dissemination to glands and the system generally. It has been found possible to transplant the disease from one animal to another, but only within the limits of the species—dog-cancer to dogs alone, and chicken-cancer to chickens, etc. It is possible to transplant mouse-cancer to rats, but the disease quickly dies out. It is essential that the living cells or a fragment of living tissue be thus transplanted, and thereby the process differs from an infection, such as tuberculosis. In the latter any cells derived from a first animal quickly die, but the micro-organisms continue to live and produce their characteristic changes in the tissues. In cancer the cells transplanted live and multiply,

and the process is really one of tissue-grafting, which may be repeated indefinitely from one animal to another.

There are, however, certain exceptions to the above statements, and it is upon the observations made in these conditions that some recent experimental work upon the subject has been based. Certain sarcomata have been found growing in chickens of the Plymouth Rock type (Rous fowl-tumours) from which can be prepared an extract, freed from cells by filtration through a suitable filter, which is still capable of transmitting the disease. Treatment by very moderate heat on the one hand, or by suitable chemical means on the other, is capable of destroying the power of this extract to convey the disease; and it has been alleged that, on adding together these two fluids, tumour-growth has again been secured. Dr. Gye, who was responsible for these observations, argued that two factors were present in this conveyance—*viz.*, a virus which can pass through a filter, and a substance which can activate the virus and enable it to develop. The ultra-microscopic virus has, it is claimed, been seen and photographed by Mr. Barnard; and these observers allege that it is common to all types of cancer, and perhaps sarcoma. The activating substance is called by Dr. Gye the specific factor, as he believes that each animal-class produces its own factor, in the presence of which alone the common virus can be effective in producing a growth. Much further work is necessary before this can be looked on as confirmed. A virus which can pass a filter and is ultramicroscopic is the recognized cause of certain other diseases—*e.g.*, foot-and-mouth disease. Their argument is that to this must be added some activating principle, in the presence of which it can cause the development of a growth in the tissues; and that prolonged irritation of the parts may induce the development of this substance, or even a blow; and preceding constitutional conditions, such as might be developed from the absence of vitamins, etc., in the diet, or from the presence of autotoxins from intestinal causes, may possibly be a predisposing factor in determining its production. They suggest that, if the activating substance develops in connection with epithelial tissues, and the virus is brought to this part, then cancer might be caused; if, on the other hand, the specific factor comes from connective-tissue cells, then the presence of the virus might lead to a sarcomatous growth. This suggestion is hypothetical, but may form a basis for further investigations.

Experiments on animals have also been fruitful in demonstrating that they possess a certain degree of **natural immunity,** since inoculation-experiments are not always followed by success. Some tumours are highly virulent, yielding a large proportion of successes, and there is usually an increase of malignancy brought about by repeated inoculations. The existence of a natural immunity is also evidenced by the fact that mice of different races show very different degrees of susceptibility to the same tumour. That immunity can be **acquired** appears from the observation that a mouse unsuccessfully inoculated with a tumour of low virulence

becomes refractory to tumours of great infective power to normal mice. The occurrence of apparently **spontaneous** or **natural cure** has also been recorded by competent observers in a number of cases in the human subject—cases verified by the microscope and given up as inoperable—proving thereby that some form of acquired immunity can occasionally be developed, but as to the cause and conditions that may produce this result we know nothing.

Cancer is characterized by the development of a primary tumour, almost invariably single, which by its continued growth infiltrates and destroys the neighbouring tissues; if it comes to the surface, it ulcerates and may become very offensive owing to the supervention of a mixed infection. The disease also spreads along lymphatics, and involves neighbouring lymphatic glands, which may break down and ulcerate; finally, general dissemination throughout the body may occur, the lungs, liver, brain, and bone-marrow being specially liable to invasion.

Any epithelial surface or organ may be affected by cancer, but it is most frequently seen in parts which are exposed to injury or chronic irritation. In the **male,** the stomach is the organ most frequently affected, and then follow in order the intestines, tongue, and mouth, etc.; 80 per cent. of all cancers in the male sex affect the intestinal canal. In the **female,** cancer of the uterus, ovaries, and breast account for nearly 80 per cent. of all cases of the disease. It is not very common in early life, but increases in frequency after thirty years, and reaches its maximum incidence between forty and fifty-five years of age.

The essential character of a cancerous growth consists in an unlimited multiplication of the epithelial cells of the organ or tissue attacked. These cells are arranged in groups or masses, and show little resemblance to the glands, etc., of the normal part. The epithelial cells themselves are also anaplastic, losing their more specialized characters, and reverting to mere masses of protoplasm which have lost all physiological powers except those of growth and subdivision. They often differ greatly among themselves in size, character of nuclei, etc., and in rapidly-growing carcinomata numerous mitoses (which may be irregular, tripolar, or multipolar) may be seen. In general, the greater the malignancy, the greater the anaplasia. There is also an alteration of the mutual relations between the epithelial cells and the connective tissue of the part. The former do not remain limited by normal basement-membranes and other mesoblastic elements, but penetrate these, producing **infiltration** of the surrounding tissues (Fig. 66), following the lines of least resistance, and usually extending along the lymph-spaces. There is thus no longer a sharp and definite line of demarcation between the epithelial and connective-tissue portions of the tumour (as in innocent growths), but the two are inextricably blended.

Marked changes occur in the connective tissues around the cancer; they are irritated by the growth, and become infiltrated with 'small round cells' and plasma-cells, and undergo a greater or less degree

of organization, leading to the development of a stroma of variable density and vascularity around the invading epithelial cells. In chronic cases the stroma is usually fibro-cicatricial in type and contains few bloodvessels; in the more actively growing parts and in acute cases the stroma is comparatively scanty, more cellular, and vascular. When ulceration has occurred, polymorphonuclear leucocytes are usually abundant, and other inflammatory manifestations may be seen; pyogenic bacteria may be detected in the growth.

Cancerous tumours are not necessarily tender to the touch, but a considerable degree of pain, usually of a neuralgic type, is often

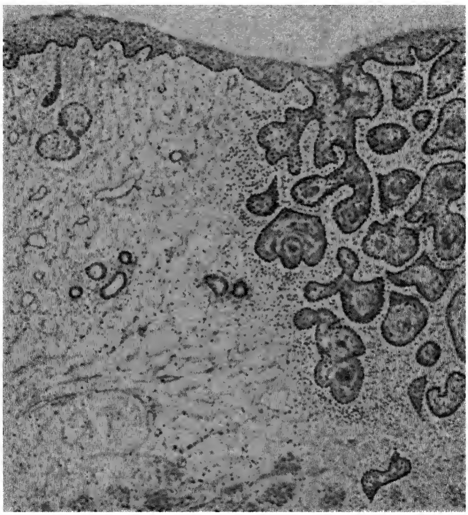


FIG. 66.—SQUAMOUS EPITHELIOMA.

Very low-power view to show the invasion of the deeper tissues by the proliferating malignant surface cells and formation of 'cell-nests.' (× 30.)

present, especially in the harder forms when the tissues are dragged upon by the contracting stroma.

The enlargement of the neighbouring lymphatic glands is usually an early and important sign, but it must be remembered that, when the primary growth has a dirty ulcerating surface, the enlargement may be due in part to the absorption of bacteria and toxins, and treatment directed to cleansing the surface of the sore may lead to a considerable reduction of the enlargement.

The **Prevention** of cancer has attracted a great and growing amount of attention during recent years in view of the alleged increasing death-rate* from this cause. Much has been written as

* This alleged increase may be due in large part to the greater accuracy of modern diagnosis. Mortality statistics are at best still very unreliable.

to the influence of diet, and the most conflicting instructions have been given as to what to eat and what to avoid. No general rules can be formulated that will meet all requirements, and the adoption of a simple diet that suits the digestion of the individual, including a certain amount of fresh fruit and vegetables, is all that can be advised. The all-important element in the direction of prevention is the avoidance of preventible sources of irritation, whether local or general. The bowels should be kept regular so as to eliminate intestinal toxins, but one good evacuation a day is sufficient. Early attention to all slight local troubles in the body is essential, *e.g.* patches of leucoplakia on the tongue or elsewhere, ulcers from rough teeth or dental plates, etc., a torn cervix uteri, or a small lump in the breast, etc. It is possible that the tissues of syphilitic patients are more vulnerable than those of healthy individuals, and therefore increased watchfulness is required in such cases.

Varieties.—Cancers are classified as epithelioma, columnar cancer, or spheroidal-celled cancer, according to whether the epithelium from which the tumour is derived is of the squamous, columnar, or spheroidal type. The term 'colloid cancer' is used to indicate a degenerative change occurring in some forms.

1. **Epithelioma** (*syn.:* **Squamous Epithelioma, Epithelial Cancer**).—By this term is meant a cancerous tumour growing from skin or from those portions of the mucous membranes which are covered with squamous epithelium.

Squamous epithelioma usually occurs in middle-aged or elderly individuals, occasionally earlier in life. Any part of the skin may be the site of this tumour, as also the mucous membrane of the mouth, pharynx, and œsophagus, and that lining the genito-urinary tract. It commonly results from some long-continued irritation, as on the lip or tongue, whilst upon the penis it is usually associated with a long foreskin. Old scars, especially if they become ulcerated, are liable to such malignant change, and the disease may supervene on intractable lupus.

Clinically, epithelioma may be looked upon as a **malignant wart,** which not only grows outwards from the surface, but also burrows deeply into adjacent tissues (Fig. 66); sooner or later ulceration follows. Several characteristic forms are described: (*a*) It may occur as a nodular indurated mass, with hard everted edges and central ulceration, giving rise to a somewhat crateriform ulcer (Fig. 67). (*b*) The destructive process may follow closely upon the new formation, leading to the appearance of a depressed sore (**malignant ulcer**) with sharply-cut edges, and resembling a rodent ulcer. (*c*) Occasionally the superficial outgrowth is excessive, and the destructive process limited, giving rise to a projecting cauliflower-like mass, which is soft and bleeds easily (**malignant papilloma**). (*d*) A **chronic epithelioma** is sometimes seen, in which the fibrous stroma contracts and compresses the columns of epithelial cells; the surface is then indurated and wart-like, with but little ulceration, whilst the base is very hard, and the progress of

the disease much less rapid than in other forms. This variety is not uncommon on the lip.

The disease, as a rule, early infects neighbouring lymphatic glands, which become the seat of a similar growth, and, if superficial, sooner or later involves the skin and gives rise to characteristic ulceration. As the disease advances, more distant groups of lymphatic glands are attacked; it is unusual to find this form of cancer disseminated through the internal viscera. The glands sometimes become cystic, especially in the neck, and on cutting into them a thin, turbid fluid like sero-pus escapes, mixed perhaps with white masses of epithelial débris; from time to time similar material is discharged through the resulting **sinuses.** Death may occur from septic broncho-pneumonia, or from hæmorrhage resulting from ulceration into the main vessels of the neck; otherwise the fatal termination is due mainly to cachexia and exhaustion.

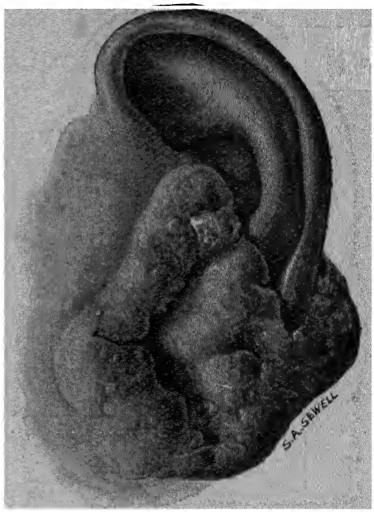


Fig. 67.—Typical Epitheliomatous Ulcer, showing Heaped-up Margins and Deep Central Crateriform Excavation. (College of Surgeons' Museum)

Microscopically, an epithelioma consists of masses of epithelial cells (Fig. 68), invading and ramifying in the subjacent tissues, and interlacing freely with each other, so as to produce an irregular network, the meshes of which are occupied by a fibrocellular stroma and the remains of the invaded tissues. The true cancer-cells are derived from the prickle-cell layer of the epidermis (**acanthoma**), but in rapidly-growing cases the prickles may not be in evidence. The cells in contact with the stroma are usually regular, and resemble the basal layer of normal skin; the cells next to these are polygonal in shape, and in the deepest layers may become flattened and undergo imperfect keratinization. This differentiation is best seen in the cell-nests which develop in the substance of the invading cell-masses; they are most common in comparatively chronic cases, and may be absent in the rapidly-growing forms.

2. **Malignant Adenoma** or **Adeno-carcinoma,** including **Columnar-celled Carcinoma,** etc. (Fig. 69). This tumour may arise from the secreting epithelium of glands, from their ducts, or from mucous membranes, *e.g.* those of the alimentary canal, where it forms a projecting growth from the surface, and also penetrates deeply into the submucous and muscular coats. The deep processes retain an

imperfect alveolar arrangement, and between them is found a certain amount of stroma. In the more chronic forms the stroma is abundant, and fibro-cicatricial in character; in the softer and more rapidly growing forms the stroma is less abundant, and fibro-cellular in nature. The alveoli vary in shape, and the epithelial elements are irregularly arranged. If a large section, including the whole thickness of the intestinal wall, is examined, the extension of the glandular tissue into and between the muscular fasciculi indicates the malignant nature of the case. Ulceration usually occurs, giving rise to a typical lesion, surrounded, in the more chronic forms, by

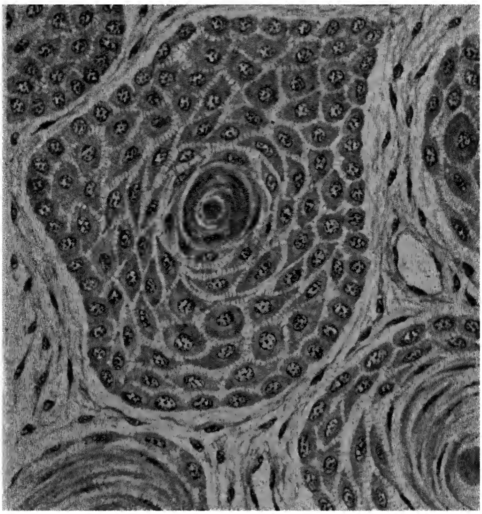


FIG. 68.—SQUAMOUS EPITHELIOMA.

High-power view to show the reversed arrangement of the epithelial cells and the formation of 'cell-nests,' the surface epithelial cells of the stratum corneum being now centrally placed, and the formative Malpighian cells proliferating at the periphery of the invading masses. (× 300.)

indurated and everted edges. Neighbouring lymphatic glands are implicated, as in the case of all cancers, whilst later on the disease spreads to the viscera, and may be generally disseminated. A similar type of growth occurs in the cervical portion of the uterus, and occasionally in the ducts of glands, such as the liver and breast. It is also met with in the superior maxilla, originating in the tubular glands of the mucous membrane lining the antrum.

3. **Spheroidal-celled Cancers** are those in which the acinar structure is lost, and the cancer-cells are found in solid groups of varying size, infiltrating through the basement-membrane and invading the surrounding tissues. The amount of stroma varies

considerably, and, according to whether it is abundant or scanty, the tumour is hard or soft in consistence, and slow or rapid in growth. To the former type the term **Scirrhus Cancer** is applied; to the latter, **Encephaloid.** All intermediate varieties between these two extremes may occur, the same tumour not infrequently showing considerable variation in different areas.

The **Scirrhus** form is met with most frequently in the breast, but also occurs in the prostate, pancreas, and pyloric end of the stomach. On naked-eye examination a scirrhus tumour appears as a hard nodular mass, the limits of which are imperfectly defined. When

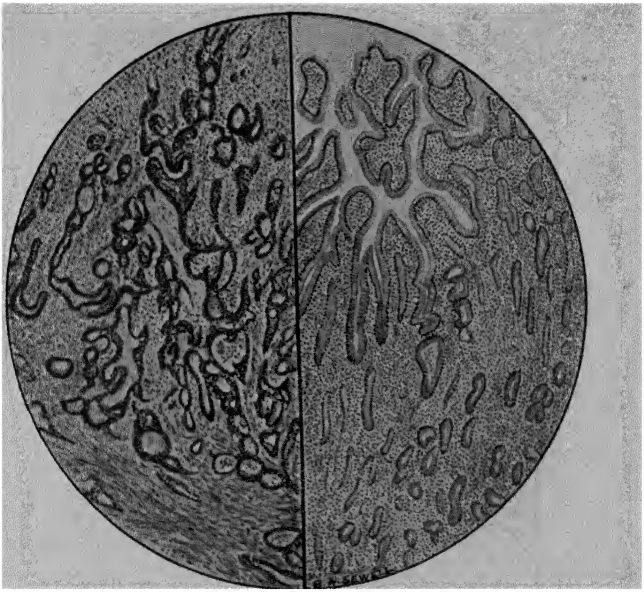


FIG. 69.—COLUMNAR CARCINOMA OF INTESTINE, COMPARED WITH NORMAL INTESTINAL MUCOUS MEMBRANE.

The right half represents the normal villi of the mucous membrane becoming slightly infiltrated with leucocytes at the left side, owing to proximity to the growth. The left half is cancerous, with irregularly shaped glandular tubules burrowing into and infiltrating the submucosa.

cut across it creaks under the knife, and presents a yellowish-white surface, which rapidly becomes concave owing to the contraction of the fibrous stroma. It has often been compared to the section of an unripe pear or turnip, both on account of the grating sensation imparted to the knife and from its appearance. On scraping the cut surface with the blade of a knife, a typical cancer-juice is obtained, consisting of epithelial cells and débris.

On microscopical examination, the tumour is found to consist of the invading cancer-cells, usually in small irregular groups or masses,

separated by an abundant and fully formed fibrous stroma resulting from the irritation and proliferation of the pre-existing connective tissue of the part (Fig. 70). In the older and more central parts of the tumour, degenerative changes are often present, small cysts being occasionally produced in this way. At the periphery the growth may be seen extending in all directions along the tissue-spaces and lymphatics, whilst a round-celled infiltration of the surrounding tissues is also evident.

Where the stroma is very excessive, the cell-elements, and, indeed, the whole tumour, may undergo a considerable degree of atrophy,

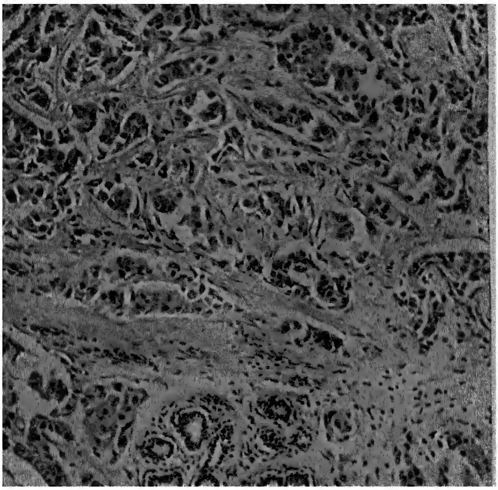


FIG. 70.—SCIRRHUS MAMMÆ (× 120.)
(A lobule of normal breast tissue is seen at the lower margin.)

owing to compression of the nutrient vessels, constituting the variety known as **atrophic scirrhus.**

Encephaloid, Medullary, or **Soft Cancer** (Fig. 71) is a term applied to a growth of a similar nature, in which the stroma is much less abundant than the cell-elements. It constitutes a rapidly-growing tumour, much softer than the scirrhous form, and very early infiltrating surrounding parts and affecting neighbouring lymphatic glands. The skin over such a tumour, *e.g.* if in the breast, is stretched, and dilated blue veins may be seen through it. Ulceration occurs early, and from this surface a foul, bleeding, fungating mass develops (Plate II., Fig. 2). Encephaloid cancer may attack the breast, testis, kidney, and a few other glandular organs.

On section it is found to be composed of a soft whitish mass, somewhat resembling brain-substance (hence the term 'encephaloid'). It is usually very vascular, perhaps pulsating, and hæmorrhagic

extravasation into its tissues is not uncommon. An abundant juice is obtained on scraping.

4. **Colloid Cancer** results from a degeneration of the epithelial cells of any of the above-described types of cancer. Its most frequent site is within the abdominal cavity in connection with cancers arising from the stomach, intestine, or omentum. To the naked eye it presents an alveolar texture, the spaces being filled with translucent gelatinous material of varying density. Microscopically, the epithelial cells are progressively replaced by a structureless colloid substance. Towards the growing margin, the cells may be seen in process of degeneration, globules of the material forming within them and pressing the nucleus to one side.

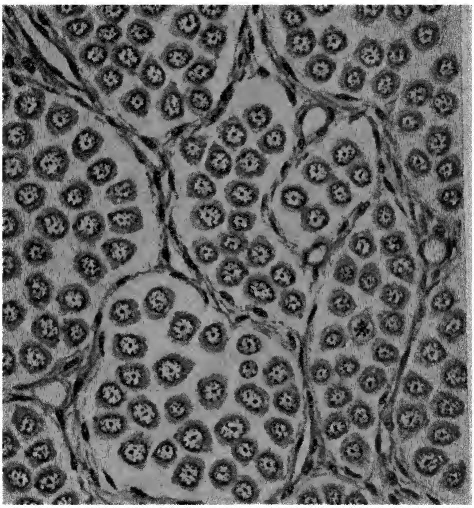


FIG. 71.—ENCEPHALOID OR MEDULLARY CANCER OF THE BREAST.
The actively proliferating epithelial cells show an alveolar arrangement, with a surrounding fibrous-tissue stroma containing the bloodvessels. (× 300.)

Endotheliomata.—The **endothelial cells** of bloodvessels, lymphatic vessels and spaces, and serous cavities, are, physiologically speaking, lining cells; but, as they are originally derived from the mesenchyme, they may easily show reversion to pulp-tissue characters. This is well seen in inflammations, both acute and chronic, in which these cells proliferate and take an active part in the reactions against organisms and their toxins, and in the reparative processes seen in granulation-tissue, etc. Marked, and sometimes extreme, proliferation of the endothelial cells of the adenoid reticulum of lymph-glands, *e.g.* in some forms of tuberculosis, or in the pulp of the spleen, *e.g.* in Hodgkin's disease (lymphadenoma) or in Gaucher's disease, may

lead to appearances closely simulating neoplastic transformation. Indeed, in the last-mentioned condition, Gaucher's disease, opinions still differ as to whether it is of chronic infective or of neoplastic nature.

Definite tumours of endotheliomatous nature are by no means rare, and form a large and important group, which as a class are distinctly less malignant than the sarcomata or carcinomata, to which they often bear close structural resemblances. They are usually slow in development, but often recur locally after removal, and may in time affect glands or form secondary deposits in internal organs. Their most important sites are the meninges of the brain and cord, and the pleura or peritoneum, but they may occur in any part of the body. The cells constituting an endothelioma are derived from the pre-existing endo-

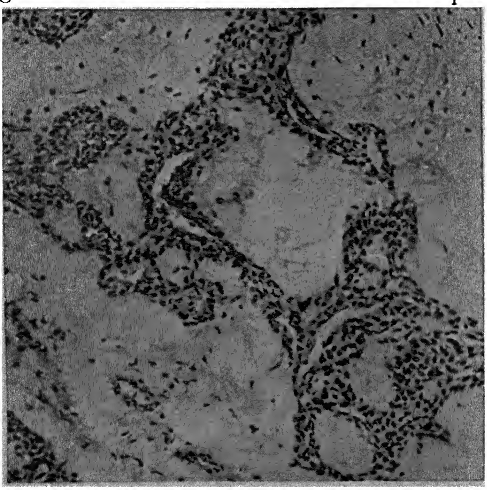


FIG. 72.—PERITHELIOMA. (× 120.)

thelium of the region, and they become spherical, cuboidal, or even columnar in shape, and take on independent growth. The tumour may start in the lymphatic clefts, which then appear to be filled with cuboidal cells, forming a cellular network having some general resemblance to a carcinoma. In some cases the cells affected are those lining the smaller lymphatic vessels, and in others this may involve especially those occurring in the vascular sheaths, forming a cellular investment to the smaller vessels—**perithelioma** (Fig. 72). In a third group the endothelium which takes on morbid growth is that which lines the bloodvessels themselves.

Endothelioma of the pleura is an important member of this group, and may spread widely and invade the lung and neighbouring structures.

The endotheliomata which occur in the central nervous system are usually composed of spindle-shaped cells, which have a tendency to

organize into fibrous tissue, and have a curious arrangement in whorls, something like those of a 'cell-nest.' The central portions of these masses frequently undergo a variety of hyaline degeneration, and may subsequently become calcified. These tumours are called **Psammomata.** Endotheliomata of the meninges are not uncommon, and are generally superficial, readily shelled out, and may not recur after operation.

Treatment of Cancer.—That cancer can be extirpated in a considerable percentage of cases by early and well-planned operation cannot now be doubted, but the prognosis of such treatment depends entirely on the stage of the disease. Until medical practitioners realize the significance of the early manifestations and will give the time and take the trouble to investigate cases thoroughly, we shall not improve matters much. The public also must be educated by lectures, pamphlets, etc., as to the early phenomena, and advised to consult their doctors when they suddenly discover lumps or develop unpleasant or uncomfortable symptoms. All medical men ought to take their share in thus instructing the general public, not only in the nature and early manifestations of cancer, but also as to the chances of cure and the inevitable danger of delay. The main reliance, of course, is still in operation, but experience of radio-therapy (p. 319) has shown that in it we have a valuable adjunct, and in suitable cases an effective alternative.

Operative treatment consists in the removal of the tumour, together with a wide margin of healthy tissue around it, or in some cases of the whole organ or limb affected, as well as of the lymphatic area concerned, and, if practicable, in one mass, so as not to cut across the lymphatic vessels passing from the growth to the glands. The wide area of permeation by the cancer-cells, and the impossibility of recognizing by the naked eye their existence in the tissues, explains the extensive scope of such operations, and the only too frequent recurrence locally or in the course of the lymph-stream. In spite of this, however, better results are being obtained, thanks in part to our increasing knowledge of the lymphatic distribution, and in part to the improvement in our surgical technique, which justifies more extensive operations. The introduction of the use of the **electro-cautery knife** and **needle** for the making of incisions and for excising malignant growths constitutes a notable advance in surgical technique, the cancer-cells encountered being killed in place of being disseminated by the ordinary surgical knife. That surgeons can now report 17 to 50 per cent. of their patients operated on for cancer of the breast as alive and free from recurrence at periods varying from six to thirteen years is indeed a matter for congratulation; 237 operations for cancer of the uterus showed 38 per cent. of the patients free from recurrence after an interval of five years; of 114 cases of cancer of the lip, 53 per cent. were alive and well, or dead from some other disease, more than three years after operation (Göttingen clinique). Results such as these, which could be easily supplemented, prove that cancer can be successfully extirpated by

operation if it be recognized early enough, but it is only from **early diagnosis** that we can hope for better results.

The **non-operative** treatment of cancer may be justified in cases where the disease is very superficial—*e.g.*, rodent ulcer, and some forms of epithelioma—or where it is impossible to remove it completely by operation.

The introduction of **radio-therapy** has placed at the surgeon's disposal an agent which in suitable cases may be effective, but in the more deeply placed cancers it is of little use. Its value and limitations are discussed at p. 319. Radiation both before and after operation is now also much employed.

Promising results have been reported by Professor Blair Bell of Liverpool in the treatment of inoperable cancer by the intravenous injection of colloidal lead. This work is still in the experimental stage, and is not free from danger (*e.g.*, the production of nephritis, etc.); but it appears probable that certain salts of lead have a definite power of inhibiting the growth of cancer-cells, and possibly of causing their absorption, and also rendering them more sensitive to irradiation. Much more work, however, must be undertaken before the method can be looked on as established, but the fact remains that a certain number of individuals who might have died long ago are still working and in good health after treatment of this type.

Apart from such measures, there are no 'certain cures' for cancer. Many substances have been vaunted in this direction, but careful trials under trained observers have always resulted in disappointment. In some few instances the growth of the tumour has been hindered by tying the nutrient vessels—*e.g.*, the external carotid and its branches in malignant tumours of the head—and pain has been relieved by division of sensory nerves. In ulcerating cases, the adoption of careful aseptic methods and the use of a suitable vaccine may reduce the inflammatory reaction, and cause temporary improvement. In the final stages, morphia or heroin can alone be depended upon to give to the patient some relief from pain.

B. **Teratomata.**

By the term **teratoma** is signified a mixed tumour which includes in its substance derivatives of all three germinal layers (epiblast, mesoblast, and hypoblast). Sometimes the tissues are arranged in a more or less orderly fashion, and represent more or less well-defined types of adult tissue; the growth is then termed a **typical** or **adult** teratoma. If, however, the tissues are incompletely differentiated and wanting in orderly arrangement, the growth is an **atypical** or **embryonic** teratoma. The origin of these tumours is not yet definitely known, but the general impression is that they are due to the inclusion within the body of the products of another individual of the same species, such inclusion developing along its own lines and being autonomous. In some of the growths it has been possible to demonstrate chorionic villi, which goes to prove their embryonic origin without doubt.

The commonest example of this type of growth is the **dermoid of the ovary,** which may be unilocular and grow to a large size. Its lining-wall is obviously cutaneous in nature, and from it an abundant development of cutaneous appendages, such as hair, nails, teeth, nipples, mammæ, etc., is sometimes observed. Most commonly the cyst is filled with greasy sebaceous material and with an abundance of hair, which is said to be influenced in the same way as that on the scalp, becoming gray or being shed at the same time. Sometimes the tumour is more complex, containing structures such as bone, muscle, gland-tissue, etc., which are formed from all three layers of the embryo; in some rare instances large portions of an embryo, such as imperfectly developed viscera or a limb, are recognizable. Similar dermoids are found in the testis.

Teratoid Tumours are a somewhat analogous group due to intermingling of tissues of the **same** individual, early in development, *e.g.* the so-called '**mixed tumours**' of the parotid or other salivary glands, in which cartilage may occur along with adenoma: rhabdomyoma of the kidney, etc. Tumours may also arise from developmental errors in connection with embryonic clefts, *e.g.* in the neck, or along the middle line of the body, or from fœtal remnants which should normally become atrophied. These tumours are frequently cystic in character and may conveniently be dealt with shortly in the following section on cysts.

CYSTS.

By a cyst is usually meant a more or less rounded cavity, with a distinct lining membrane, distended with some fluid or semi-fluid material. The term is used very loosely, being applied to a variety of manifestations which it is difficult to classify, owing to the fact that conditions which are pathologically similar in origin are sometimes termed cysts in one part of the body, and not so in another. For practical purposes, however, they may be grouped as follows:

I. **Cysts of embryonic or fœtal origin,** or arising in connection with embryonic or fœtal remains.

II. **Cysts arising from the distension of pre-existing spaces** (**distension cysts**).

III. **Cysts of new formation.**

IV. **Cysts** (or, more accurately, **false cysts** or **pseudocysts**) **of degeneration.**

I. Cysts of Embryonic or Fœtal Origin, or arising in Connection with Embryonic or Fœtal Remains.

1. **Dermoids** are characterized by the existence in abnormal situations of cavities lined with epithelium, from which may be developed such cutaneous appendages as hairs and nails, whilst the space is usually occupied by sebaceous contents. The structure of the lining

wall is very similar in nature to skin or mucous membrane, consisting of stratified epithelium, from which a considerable growth of sebaceous glands and hair-follicles often takes place. If teeth or more complex tissues, such as bony alveoli, mammary glands, nipples, etc., develop in such a cavity, it should be looked on as a teratoma.

Several varieties of dermoids are described:

(*a*) **Sequestration-Dermoids** are cysts arising from the incomplete disappearance of surface epithelium in situations where, during embryonic life, surface developmental segments coalesce. Thus, in almost any part of the middle line of the body such tumours may develop, owing to the fact that there is here a union of two lateral segments. Similarly, they are not uncommon about the face and neck, occurring along the lines of the facial and branchial clefts. Perhaps the most common position for them in this region is the upper portion of the orbito-nasal cleft, behind, and to the outer side of the eye (Fig. 73). It is not unusual to find the skull defective beneath them, and a pedicle extending from the deep side, connecting them with the dura mater. Sequestration-dermoids appear as rounded, definitely limited tumours, firm and elastic to the touch, and over which the skin glides freely, but they are usually somewhat adherent to the deeper parts. This form of dermoid may be removed without difficulty, but, in those occurring about the scalp, with the bone hollowed out beneath them, it is perhaps advisable to delay operation till adult life, unless they are rapidly increasing in size. The reason for this is that the bone gradually grows up around the pedicle, and thus closes the communication with the cranial cavity. In some cases it may be difficult to remove the whole of the lining membrane by dissection, and under these circumstances the portion left behind should be destroyed by cautery or caustics; otherwise, recurrence is almost certain to follow.

FIG. 73.—DERMOID CYST GROWING AT THE OUTER ANGLE OF THE ORBIT (BLAND-SUTTON.)

(*b*) **Tubulo-Dermoids** arise in connection with embryonic or fœtal canals and passages, such as the thyroglossal duct and the post-anal gut (*q.v.*).

(*c*) For **Ovarian Dermoids**, see p. 245.

2. **Cysts** occasionally arise in connection with the formation of the **teeth**; such have been already mentioned under the terms follic-

ular and epithelial odontomes (p. 216), the former being also known as dentigerous cysts, the latter as fibro-cystic disease of the jaw.

3. Various **cysts** develop in connection with the **remains of the Wolffian body,** as also from its **tubules** and **duct.** It must be remembered that this body (the mesonephros) arises on the posterior abdominal wall, together with the kidney and testis, and that part of it enters into the formation of the latter: hence the fact that its remains are closely associated with that organ in the scrotum (Fig. 74). In the **male** the Wolffian body atrophies almost completely, being represented by a few blind tubules, situated close to the epididymis, and known as the paradidymis, or organ of Giraldés (P). The majority of the ducts of the Wolffian body form the vasa efferentia testis; a few, however, are attached only at one end, and their free ends (ph, V.T) may become dilated, and form small cysts, situated close to the hydatid of Morgagni (sh), which structure represents the remains of the **Mullerian body** and **duct.** It is possible that an encysted hydrocele of the epididymis sometimes arises from one of these unobliterated tubules. The main duct of the Wolffian body forms the lower portions of the epididymis (Ep) and vas deferens (V.d).

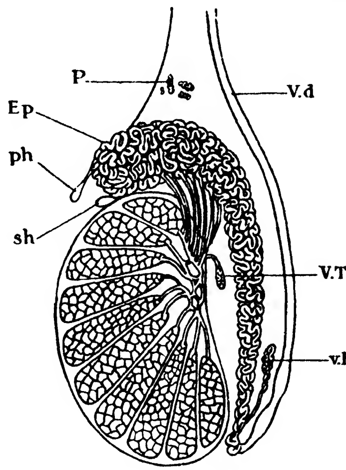


FIG 74.—DIAGRAM OF ADULT TESTIS, TO SHOW RELATION OF VESTIGIAL REMAINS.

P, Paradidymis (organ of Giraldés); Ep, epididymis; ph, pediculated hydatid; sh, sessile hydatid; v.H, vas aberrans of Haller; V.T, vas aberrans of rete testis; V.d, vas deferens.

In the **female** (Fig. 75) the remains of the **Wolffian body** may sometimes persist as a series of closed tubes (paroöphoron, P) in the broad ligament not far from the ovary. **Cysts of the Paroöphoron** may arise in connection with this structure, and are characterized by their inner walls being liable to become the seat of proliferating papillomata. The Wolffian tubules can almost always be recognized in the broad ligament, constituting the epoöphoron (Ep), parovarium, or organ of Rosenmüller. **Parovarian Cysts** formed from the distension of this structure are usually unilocular, and filled with a clear limpid serous fluid; they have no definite pedicle, growing within and separating up the layers of the broad ligament. Some of the terminal tubes may be converted into small cysts which project from the fimbriated ends of the Fallopian tube, and are known as hydatids or cysts of **Kobelt's tubes.** The main Wolffian duct generally atrophies, but occasionally persists between the layers of the broad ligament close to the uterus, and may open in the vagina near

the urethral orifice, being then known as **Gaertner's duct** (d.G). Cysts may occasionally arise in connection with this structure, projecting into the lateral fornix of the vagina.

4. The **processus vaginalis,** or **funicular process,** is the term applied to the protrusion of peritoneum which precedes the testis to form the tunica vaginalis, and which in the female accompanies the round ligament as the **canal of Nuck.** Normally it becomes obliterated, but sometimes portions remain patent, and become

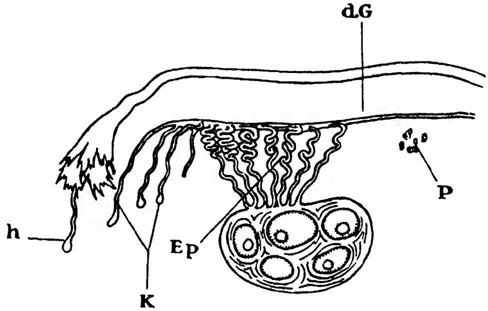


FIG. 75.—DIAGRAM OF OVARY AND FALLOPIAN TUBE, TO SHOW POSITION OF FŒTAL REMAINS.

h, Hydatid of Fallopian tube; K, Kobelt's tubules with hydatids; Ep, epoophoron (organ of Rosenmüller); P, paroöphoron; d.G, duct of Gaertner.

distended with a clear straw-coloured serous fluid, constituting in the male an **encysted hydrocele of the cord,** and in the female a **hydrocele of the round ligament.**

5. Cysts arise occasionally in connection with some irregular development of the lymphatic spaces; thus, in the neck the so-called cystic hygroma is in reality a congenital **cavernous lymphangiectasis.**

II. Cysts due to the Distension of Pre-existing Spaces.

(*a*) **Exudation- or Distension-Cysts** arise from the dilatation of cavities which are unprovided with excretory ducts. These are frequently of inflammatory origin. Such spaces may be lined with epithelium or endothelium. As illustrations of **epithelial cysts** may be mentioned those which arise in connection with the thyroid gland, as also conditions due to the distension of the central canal of the nervous system (syringo-myelocele), and those forms of ovarian cyst which arise from distension of Graafian follicles.

Exudation-cysts lined by an **endothelial** wall are of more frequent occurrence. Enlargements of bursæ, hydroceles of the tunica vaginalis or funicular process, and some forms of 'ganglia' in connection with the sheaths of tendons, are of this nature. Diverticula or hernial protrusions of the synovial membrane of joints are known as Baker's cysts.

A **serous cyst** is supposed to arise from the distension of lymph spaces, giving rise to uni- or multi-locular cavities, lined with endothelium, and containing a limpid straw-coloured fluid. They are seen most commonly in the neck, axilla, or breast, and in the latter structure may be surrounded by dense fibrous tissue. They may be looked on as **cavernous lymphangiomata.**

Adventitious bursæ arise as a result of repeated irritation, and are dealt with elsewhere.

(*b*) When a collection of blood forms in a pre-existing cavity, a so-called **Cyst of Extravasation** is produced. This is found in the pelvis or in the tunica vaginalis (hæmatocele), and also occasionally on the surface of the brain, constituting an arachnoid cyst.

(*c*) **Retention-Cysts** arise from obstruction to the escape of some natural secretion from a gland duct or tubule. The cavity thus formed is lined with epithelium, whilst, owing to the irritation produced by the tension, a fibro-cicatricial wall of variable thickness is developed outside. There is sometimes a considerable formation of intracystic growths, especially in the breast, whilst the contents generally consist of the inspissated secretion, perhaps mixed with blood. Retention-cysts may develop in connection with any glandular tissue. The majority are described under the appropriate headings—*viz.*, mammary cysts, renal cysts, pancreatic cysts, etc.

III. **Cysts of New Formation.**

These may occur apart from any embryonic condition or pre-existing cavity. The following varieties may be described:

(*a*) An **Implantation-Cyst** is one which arises from the accidental intrusion into the subcutaneous or submucous tissues of epithelial cells which retain their vitality, and are enabled to develop a cyst very similar in nature to a dermoid; in fact, it may be looked upon as an acquired or traumatic dermoid. Such an occurrence is brought about usually as the result of an injury, especially from punctured wounds; thus, cysts of this nature have been met with in the fingers or palm of the hand as a consequence of the penetration of some sharp instrument, whilst they are also occasionally seen in the anterior chamber of the eye, following accidental injury or an iridectomy. They are, moreover, observed in the axillæ of cattle, as a result of goading them with a sharp implement. The clinical signs and treatment are similar to those of a dermoid cyst.

(*b*) **Parasitic Cysts** are produced by the irritation caused by the growth within the tissues of certain living organisms. Thus, in the disease known as **trichinosis** (trichiniasis or trichinelliasis), derived from eating infected pork, *Trichinella* or *Trichina spiralis*, a minute round worm, develops in large numbers in the muscles, and becomes surrounded by a capsule which subsequently usually undergoes calcification.

The most important of these parasitic cysts is that caused by the development within the body of the scolex stage of *Tænia*

echinococcus, giving rise to what are known as **Hydatid Cysts.** This disease is much more common in Australia and New Zealand than in this country. *Tænia echinococcus* (Fig. 76) is a small tape-worm, less than half an inch in length, which inhabits the intestinal canal, especially of dogs; it consists of four segments, the posterior one being larger than the rest of the body, and containing the mature genital organs. When mature, this last segment becomes filled with ova, which are discharged, and these find their way into the human stomach from handling the dog, or, though probably less commonly, by the media of water or uncooked vegetables, such as watercress, which have been contaminated with the dog's excreta. The process of digestion sets the embryo free, and by means of a crown of little hooks which it possesses (Fig. 77), as well as four suckers, it is enabled to bore its way through the walls of the stomach, and thence travels by the bloodvessels to the liver, where it may settle down, or, less frequently, be carried on to the lung or to some other part of the body. As a result of the irritation caused by its presence, a sac forms, which originally consists of three layers: externally, a fibro-cicatricial layer, then an intermediate lamellated layer of chitinous material (true ecto-cyst), and finally the cyst is lined by a protoplasmic germinal layer (endocyst), from which may be developed solitary tænia heads or scolices, also provided with four suckers and a circlet of hooks; sometimes groups of them, known as brood-capsules, may arise in the same way (Fig. 78). Daughter-cysts are not infrequently formed from the scolices, and they in their turn may pass through the same changes, although as a rule they are barren. Occasionally even the main cyst may be sterile (acephalocyst), and in such cases the walls become very definitely laminated. The fluid contained in the cyst varies much in amount, but is always of low specific gravity, not more than 1007; it is colourless, but slightly opalescent, limpid, and contains but a trace of albumen, although a considerable amount of chloride of sodium is present. On examining the fluid microscopically, the characteristic hooklets may be observed. The organs usually affected by hydatid disease are especially the liver, lungs, kidneys, and brain, but any part of the body may be attacked. Occasionally in the liver, and usually in bone, multiple cysts develop quite

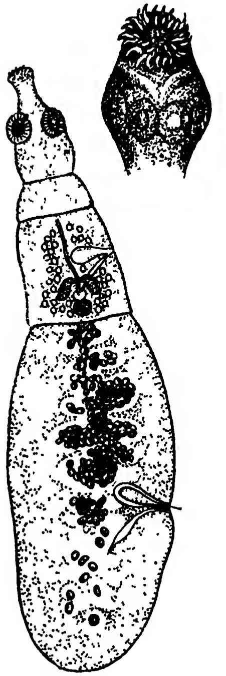


FIG. 76.—TÆNIA ECHINOCOCCUS. (× ABOUT 20.)

The upper figure is an enlarged drawing of the head, showing the circle of hooklets and suckers.

distinct from each other, and with no general cyst-wall (exogenous multiplication). This can occur only when the ectocyst is thin,

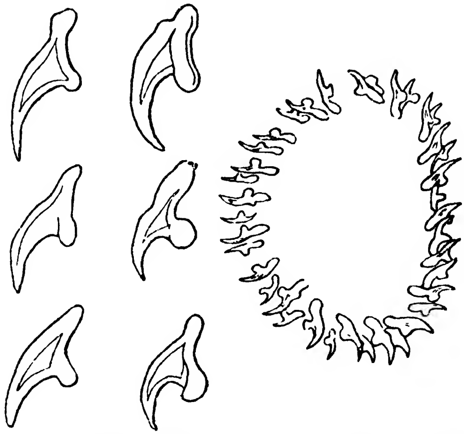


FIG. 77.—CIRCLE OF HOOKLETS AND ENLARGED VIEW OF INDIVIDUAL HOOKLETS. (AFTER CRABBE.)

allowing the scolices, which always have a retractile neck, to push through and 'swarm off' into surrounding tissues.

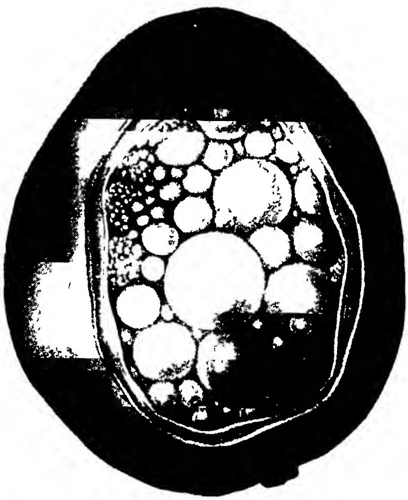


FIG. 78.—HYDATID CYST (DIAGRAMMATIC), SHOWING DAUGHTER-CYSTS AND BROOD-CAPSULES GROWING FROM THE WALLS. (AFTER BLAND-SUTTON.)

Hydatid cysts give rise to no special symptoms, except those caused by their size and situation, and they are likely to go on growing until operative treatment becomes imperative on account of

some complication, or from the size of the mass. At any time the cyst may rupture, either spontaneously or as the result of some injury; if into a serous cavity, such as the peritoneum or pleura, this becomes infected, and an abundant development of scolices and cysts ensues, giving rise to considerable localized inflammatory reaction; moreover, the escape of the cyst fluid may cause serious toxæmia, or, at any rate, urticaria, owing to the presence therein of some toxic substance.

Occasionally the parasite dies spontaneously, and then the cyst shrivels up, and the laminated walls and daughter-cysts form a firm leathery mass, perhaps infiltrated with lime-salts and of the consistency of wet mortar; a thick fibro-cicatricial capsule encloses the whole. At other times suppuration takes place within the cyst, and an abscess results. If acute, it bursts either externally, or may open into some serous cavity or hollow viscus. Sometimes the abscess becomes chronic and encapsuled, and may then remain quiescent for years.

Assistance in the diagnosis of hydatid disease may be obtained by the following laboratory tests: (1) A leucocyte-count and the examination of stained blood-films may reveal an eosinophilia; (2) an intradermic test may be performed by inoculating cyst-fluid between the layers of the skin; no reaction results in a normal person, but in an infected patient an area of hyperæmia and œdema appears round the site of inoculation within a few minutes, a delayed reaction also following later; (3) a complement-fixation test (see p. 21) may be performed on the patient's blood-serum, using fresh cyst-fluid or a saline extract of the scolices as antigen; (4) a precipitin-reaction (p. 19) may be obtained between the patient's serum and a similar antigen; this reaction is less delicate than the complement-fixation test.

For the diagnosis and treatment of hydatid cyst of the **liver,** see Chapter XXXVIII. In other regions, if the mass cannot be removed by dissection, reliance must be placed on drainage, where its situation renders this practicable, or aspiration, since it is usually found that removal of the fluid contents causes death of the organism, probably by altering the intracystic tension.

IV. **Pseudocysts or False Cysts.**

(*a*) **Pseudocysts** may form **around foreign bodies,** which thus become encapsuled. They are lined with granulation-tissue or endothelium, surrounded by a variable amount of fibro-cicatricial tissue.

(*b*) **Blood Cysts** are of variable origin. Some certainly arise from extravasation of blood, and are then filled with coagulated blood, or a thin serous fluid with a varying amount of laminated fibrin. In many cases a so-called blood cyst is really a soft sarcoma into which hæmorrhage has occurred; but a few instances are on record in which a thin-walled cavity existed, occupied by blood, and readily refilling after it had been tapped, and with no evidence of any growth. Such conditions have been most frequently observed in the neck (see Chapter XXXV.).

(*c*) **Cysts of Degeneration** arise in connection with tumours, especially those where the blood-supply is not very abundant. Thus, mucoid degeneration is not uncommon in fibromata, fibro-myomata, chondromata, and even in the harder forms of cancer. Occasionally cysts form in the sarcomata from this cause, but more frequently as a result of hæmorrhage.

CHAPTER IX.

WOUNDS.

A WOUND has been defined as the forcible solution of continuity of any of the tissues of the body; but the term is more commonly limited to injuries of the soft parts, involving the skin or mucous membranes. Lesions in which the skin does not participate are spoken of as contusions.

A **Contusion** results from external violence causing hæmorrhage into and laceration of the subcutaneous tissues, and may possibly be associated with injuries to deeper structures. The signs are usually very obvious—viz., **pain, bruising,** or discoloration of the part, and **swelling.** The amount of bruising varies with the part injured and the severity of the lesion; thus, in the eyelids, scrotum, and vulva, where the tissues are lax, the ecchymosis will be very extensive and of a black colour; on the scalp there is but little swelling unless bleeding occurs beneath the aponeurosis of the occipito-frontalis. Again, the condition of the patient's general health influences the amount of blood effused; a strong man in good training does not bruise nearly as much as those of a languid temperament and relaxed tissues. Blebs and bullæ may form over the injured spot, especially in connection with fractures. The changes that occur in a bruise are well known, the colour passing from a blackish-purple through various shades of brown and green to a yellow, which gradually fades and disappears; this is due to the disintegration of the red corpuscles, and staining of the tissues by the hæmoglobin thus set free, or by the products formed during its removal. When hæmorrhage has taken place into the deeper parts or under dense fasciæ, it is often some days before the bruise 'comes out,' and this may occur at some distant spot, *e.g.*, in the eyelids after a blow on the scalp, whilst it may travel along the muscular and fascial planes under the influence of gravity.

In a bruise or ecchymosis, the tissues are, as a rule, merely infiltrated with blood; but occasionally they are torn asunder, and then the extravasation is more localized, and may constitute a fluid swelling, or **Hæmatoma.** It somewhat resembles an abscess to the touch, but differs from it in having supervened immediately after an injury, and in having appeared without any heat or other sign of inflammation; moreover, though at first fluid and soft, it soon

becomes harder, whereas an abscess is preceded by a stage of brawny infiltration, and the softening occurs later. The subsequent history of a hæmatoma varies somewhat according to circumstances. (*a*) Fibrin may be deposited peripherally, leaving for a time a fluid centre, which gradually disappears, and the whole is finally absorbed. This is well exemplified in a subpericranial cephalhæmatoma, where the contrast between the peripheral fibrinous deposit and the fluid centre, through which the skull can be felt, is sometimes so accentuated as to give the sensation of a depressed fracture. (*b*) The fluid portion of the blood may be absorbed almost entirely, and the solid fibrinous residuum may become organized into a firm fibroid tumour which persists indefinitely; the mass is more or less laminated, and not unfrequently pigmented. (*c*) The fibrin may be entirely absorbed, and a slightly pigmented fibrous capsule formed containing serous fluid, and constituting a definite cyst; this is best seen in connection with the cerebral tunics (*arachnoid cyst*). (*d*) Suppuration may ensue owing to auto-infection from within the body, or from an invasion of organisms through abraded skin.

The **Treatment** of a bruise usually consists in keeping the part at rest, and applying cold or evaporating lotions. The effusion of blood may be hindered, if the case is seen early, by firm bandaging of the part over a compress of cotton-wool. In the later stages absorption of the blood may be hastened by massage. In the severer cases, where blebs or bullæ have formed or there is a likelihood of the skin sloughing, it must be carefully washed and rendered aseptic, and, if need be, wrapped in an aseptic dressing. When a tense and painful hæmatoma exists, as under the fascia lata of the thigh, recovery can be hastened and pain relieved by an aseptic puncture, followed by careful compression. In general bruising of the body from a fall or extensive injury, pain can often be relieved by applying fomentations or by a hot bath. There is usually a certain amount of fever and constitutional disturbance for a few days, and these are dealt with by purgatives and a suitable limitation of diet.

Open Wounds.—An open wound may be defined as a solution of continuity of any superficial part of the body, including skin or mucous membrane. Various kinds of wounds are described, such as the incised, lacerated, contused, punctured, poisoned, and gunshot; but, of course, the most important distinction to draw is between the infected and the non-infected.

I. **Incised Wounds.**—An incised wound is one made by any sharp cutting instrument, but occasionally one not produced in this manner may be characterized by similar appearances—*e.g.*, the skin of the knee or elbow may be cleanly split open from falling on it with the limb flexed, and occasionally a policeman's truncheon will lay open the scalp almost as evenly as if a knife had been employed.

The special features of an incised wound are as follows:

1. The hæmorrhage is free, from the fact that the vessels are cleanly divided. The amount necessarily depends on the size of

the vessels involved, and the vascularity of the part; its continuance, upon the density of the structures allowing or not of contraction and retraction of the severed ends.

2. Separation of the lips of the wound also occurs, the amount depending upon the elasticity and character of the part involved and the degree of tension to which it is exposed.

3. Bruising of the margins of the incision is absent, so that under ordinary circumstances rapid healing (by first intention) should obtain. The surfaces, to begin with, are lined by a microscopic layer of damaged tissue, some of which may be actually dead; but if suitable precautions are taken, this is absorbed, and in no way interferes with satisfactory union.

The chief dangers of an incised wound are: (1) Hæmorrhage; (2) injury to subcutaneous structures, such as nerves, tendons, muscles, etc.; and (3) the risks involved from infection.

Treatment of Incised Wounds.—Seven essentials must be attended to if healing by first intention is to be obtained—viz.:

(i.) **The Arrest of all Bleeding.**—General oozing may be stayed by exposure to the air or the pressure of an aseptic swab. Divided arteries and veins will need a ligature, but if situated close to the skin, they may sometimes be secured by passing under the bleeding spot the needle used for the suture.

(ii.) **Sterilization of the Wound and its Surroundings.**—In casualty work asepsis cannot be always assured, as the wound, though cleanly cut, is made through dirty skin, and portions of clothing, dirt, and splinters of wood or glass may be carried in. Under these circumstances the wound and its surroundings must be thoroughly purified, according to the rules given on p. 87, and a careful search made for foreign bodies.

(iii.) **The coaptation of the opposed surfaces** by means of **sutures** may now be undertaken. The substances employed for this purpose are fine silver wire, silk, horsehair, silkworm gut, and catgut. In casualty work, and for parts of the body where but little scar is subsequently desirable, as in the face, horsehair and silkworm gut, being non-absorbent, are the best; but in ordinary operative work, which will be more certainly aseptic, fine catgut or silk may be used. There are three chief varieties of sutures—viz., the buried, the deep, and the superficial.

Buried sutures may be safely inserted in order to hold the deeper parts of a wound together, if both they and the wound are aseptic, and there they may remain indefinitely; if, however, they are un-absorbent—*e.g.*, silk or silkworm gut—irritation or tension may lead to suppuration with a view to the elimination of the stitch even after lengthy intervals. Catgut of varying thickness is therefore the best material to employ, chromicized to a suitable degree according to the length of time it is desired to maintain its action (p. 330). Where permanent retention of the suture with a view to strengthening the part is desirable, and yet an element of tension is present, as in some wounds of the abdominal wall, it may be

wise to employ living sutures formed of strips of fascia lata taken from the patient; these, it has been proved, are not absorbed, but remain incorporated in the part, thereby adding to its strength.

Deep stitches, or *sutures of relaxation*, are required in cases where there is difficulty in bringing the edges of the wound together, in order to transfer the tension from the healing margin to tissues further away, the edges being thereby relaxed. For this purpose thick silk or catgut may be employed, inserted 1 or 1½ inches from the margins. Deep stitches are generally removed at the end of two or three days.

Superficial stitches, or *sutures of coaptation*, must be so inserted as to bring the edges of the wound into contact without undue pressure,

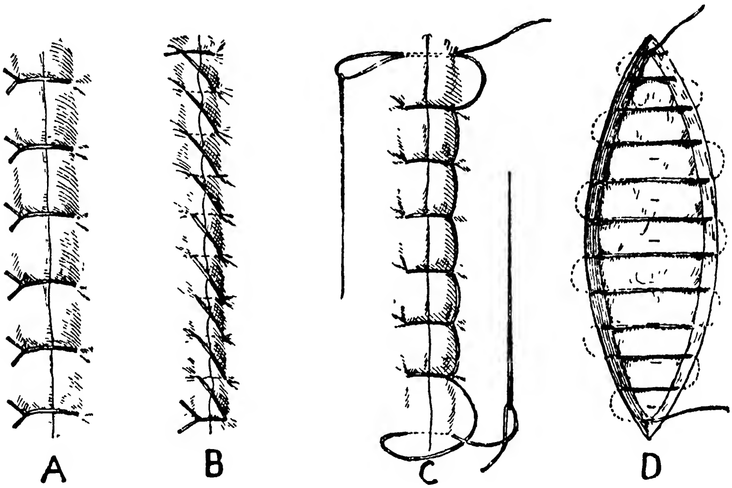


FIG. 79.—VARIOUS FORMS OF SUTURE.

A, Interrupted suture; B, continuous suture; C, blanket stitch. At the lower end the needle has just been passed, and the way in which it catches up the loop is indicated. At the upper end the method of finishing off (originally suggested by the late Mr. Maunsell) is shown; viz., the needle is passed in the opposite direction to all the other stitches, the free end being left long, so as to enable it to be tied into a knot with the double thread which the needle has carried through: D, Halstead's intradermic or subcuticular stitch.

and without any unfolding of the skin. Various methods are employed, viz.: 1. The *interrupted suture* (Fig. 79, A), in which each stitch is separately finished off, the knot lying well to one side of the incision. This is generally utilized for wounds which are of irregular shape or in which there is tension. 2. The continuous *glover's stitch* (Fig. 79, B) is not to be recommended. 3. The *blanket* or *buttonhole stitch* (Fig. 79, C) is the form of continuous suture which should be employed for extensive wounds or incisions. In it the

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needle, after traversing the lips of the wound, is carried under the slack of the thread, so that the loop of each stitch, as it is tightened, is maintained at right angles to the edge of the wound, whilst the intermediate portion lies parallel to it. 4. Halstead's *intradermic* or *subcuticular stitch* (Fig. 79, D) is employed when very exact coaptation is desirable, and to minimize visible scarring, as in the face or neck. The deeper parts are first built up by buried sutures, and then a silkworm-gut stitch is inserted by a short straight needle through the skin, as in the diagram, passing parallel to the surface and alternately on the two sides. The suture is finally pulled tight at each end and left long. To remove it, one end is cut short, and then a steady pull on the other end draws out the remainder quickly and without pain 5. A similar exact coaptation can be secured by interrupted sutures passed in the ordinary way about 1 centimetre from each edge, and then one of them is passed through the exact skin edge on both sides and tied to the other end This has been termed the eversion stitch, and may be used with advantage in fat subjects (Fig. 80); it prevents any part of the skin

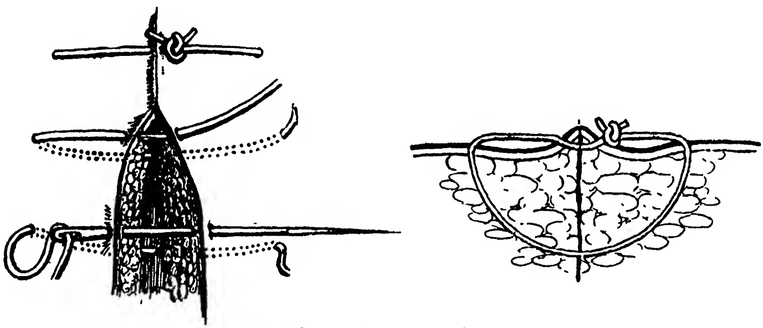


FIG. 80 —EVERSION STITCH.

edges from being inverted. 6. Metallic clips (*e.g.*, Michel's) are used by some surgeons instead of sutures, but have no real advantage.

Adhesive plaster is sometimes employed, but the wounds must be very small and insignificant which only require such treatment. A fine aseptic suture is in most cases preferable. Plaster is, however, extremely useful in the later stages to hold the wound together and prevent stretching of the scar tissue by muscular traction. Particularly is this valuable after abdominal operations where drainage has been employed. After healing is completed, the parts should be kept strapped for three to six months to allow the scar tissue to contract and become firm; by this means post-operative hernia can usually be prevented.

(iv.) **Drainage** must, if necessary, be provided, in order to guard against the irritation and tension caused by retained blood or exudations. In casualty wounds, where there is doubt as to the completeness of the asepsis or hæmostasis, or where there has been

much tearing or laceration of tissues, it is often wise to insert a tube for twenty-four or forty-eight hours.

When drainage is required, the indiarubber tube introduced by Chassaignac answers well; the end should be cut flush with the surface, and stitched to the edges of the wound, so as to prevent it slipping in or out; in later stages, if it is required, a sterilized safety-pin may be passed through it so as to prevent it from slipping into the wound. For small wounds, a strand of horse-hair or a strip of sterilized rubber glove or protective will usually suffice.

(v.) **All fresh sources of irritation and infection** of the wound must be excluded by some form of antiseptic or aseptic dressing.

(vi.) **Rest** to the injured part must be secured by such an arrangement of splints, slings, or bandages as may be necessary.

(vii.) The **general health** of the patient is a most important item. In an operation case the bowels should, if possible, be previously opened, and the patient's diet carefully regulated; in casualty work a good purge should be administered as soon as convenient.

An aseptic incised wound heals in from five to seven days, but the time to remove the stitches varies with the age and vigour of the individual, the part of the body, and the degree of tension required to close the wound. In aseptic operation wounds the stitches are usually removed on the eighth day; but in the face it is often advisable to take them out earlier.

Many conditions may arise to *prevent* the healing of an incised wound by first intention, and they may be epitomized as essentially the reverse of the seven conditions mentioned above—viz., (i.) Non-arrest of the bleeding, causing separation of the lips or deeper portions of the wound; (ii.) the presence of infected foreign bodies or failure of the antiseptic precautions; (iii.) non-apposition of the edges; (iv.) imperfect drainage, leading to tension on the stitches; (v.) late infection of the wound; (vi.) lack of rest to the part; and (vii.) constitutional conditions, such as deficient general vitality from disease or other causes.

When blood collects in the deeper parts of the wound, the skin incision may heal satisfactorily, but there may be some local tenderness, and a little swelling, and some slight fever, the temperature running up at night to about 100°. In such cases it usually suffices partially to open the incision, squeeze or press out the fluid, and insert a small tube or gauze drain. (For Wound Infection, see p. 83.)

II. **Lacerated or Contused Wounds.**—These injuries are caused by blunt instruments, by machinery, missiles, the wheels of a vehicle, etc. They are characterized by the following signs:

1. The hæmorrhage is as a rule but slight, since the vessels are torn across irregularly, and not cut cleanly; the middle and inner coats, which give way first, are curled up within the contorted outer coat, forming a barrier sufficient to prevent loss of blood.

The vessels, being elastic, may be pulled out of their sheaths, and are sometimes seen pulsating upon the surface.

2. The amount of damage inflicted varies with the character of the injury, but is often so severe as to involve the death, at once or subsequently, of considerable portions of tissue. The skin is irregularly torn, and may be extensively stripped from underlying parts; muscles and tendons may be laid bare, or torn from their attachments; nerves may be lacerated; bones crushed and comminuted; joints laid open; and all these damaged tissues may be hopelessly infected by the dust of the roadway or the dirt and grease of machinery. When a limb is torn completely off, the tendons are often left long, and the muscular bellies project from their fascial sheaths as flabby congested masses, since the skin gives way at a higher point than the subjacent structures.

The **Progress** of the case depends largely upon the question whether or not the wound can be rendered aseptic.

In an **Aseptic** lacerated wound it may be possible to bring the edges together, and, even though they are a little bruised, healing by a slightly delayed first intention is possible. When the wound remains open, the dead tissue is absorbed or separated, and an aseptic granulating surface results. There may be some simple traumatic fever for a day or two.

If the wound is **Infected,** however, inflammatory phenomena supervene, as a result of which bruised and dead tissues have to be absorbed or cast off by a process of suppuration, which finally leaves a granulating surface. Three stages may be described in the course of such a case, viz.:

(*a*) The stage of injury, resulting in shock, which may be very severe if it includes extensive muscular injury or the crushing of large nerve trunks.

(*b*) The stage of inflammation and sloughing, which lasts a week, ten days, or more, according to circumstances, and during this period various forms of infective trouble may develop, including secondary hæmorrhage, toxæmia, pyæmia, tetanus, and traumatic gangrene.

(*c*) The stage of repair by granulation, or prolonged suppuration, with exhaustion and hectic fever in the worst cases.

The results of the healing of injuries such as these may be quite satisfactory, or considerable trouble may be experienced at a later date from the implication of nerves in the cicatrix, or their paralysis; from the adhesions or cicatricial contraction of muscles and tendons, impairing the free mobility of the part; or from the deformity caused by the contraction of the scar.

The **Treatment** of contused and lacerated wounds varies with their character, and no absolute rule of practice can be laid down to suit all cases.

(*a*) **Immediate Treatment.**—All wounds of this nature are to be looked on as infected, and must be treated according to the rules already suggested (p. 87)—*i.e.*, by excision of the dead or damaged

tissues, efficient purification, and *immediate suture only if the surgeon is satisfied that complete asepsis has been secured.* Failing this, the wound is left open and packed with some suitable material—*e.g.*, gauze soaked in a solution of flavine (1 in 1,000) or infiltrated with B.I.P.P. (p. 90), and if infection is avoided delayed primary suture is undertaken.

(*b*) **Subsequent Treatment** depends on whether or not the measures adopted to obtain asepsis have been successful. If the wound remains free from infection, nothing special is required. If infection occurs, cellulitis and sloughing follow, and necessitate opening the wound freely, and following up any burrowing suppuration by free incisions. Fomentations, baths, etc., as for cellulitis (p. 79), will be required as long as the inflammatory process lasts, or the wound must be packed with gauze soaked in hypertonic saline solution. When the suppuration has ceased and the sloughs have separated, healing by granulation follows. It must be remembered that secondary hæmorrhage may occur when the dead tissues are detached. During this period inflammatory fever continues, and the patient's general health must be closely watched.

When once a clean granulating surface is obtained, it is treated in the same way as any other healing wound or ulcer (p. 108), skin-grafting being employed when necessary. If the wound is of comparatively small size, repair is generally effected quickly, but when of large size and irregular shape, especially if involving deeper tissues as in gunshot wounds, the case may be difficult to manage. A few general principles must here be laid down:

(i.) For healthy wounds with but little discharge, the direct appli cation to the granulations of *dry dressings* should if possible be *avoided*, as they stick to the surface and hinder the escape of discharge; every time they are taken off, the removal of reparative material follows, associated with the tearing of capillaries and slight resultant hæmorrhage, and hence an increase in the local irritation and a spreading more deeply of the sclerosing process which involves the tissues underlying the granulations. The interposition of a piece of sterilized protective the exact size of the wound, or of a portion of gauze soaked in sterilized vaseline, boric acid ointment or paraffin will suffice to protect the surface from this source of irritation.

(ii.) The affected part must be *kept at rest*, if need be, by splints, and freed from external irritation. The healing of many wounds is delayed by allowing the patient to get up or to move the part too soon. Especially does this apply to wounds over joints, where every movement affects the shape and size of the healing area, and to wounds with muscle-bellies exposed in their depths merely covered by a layer of granulations. One full range of movement to the joints above and below the lesion each day is sufficient to keep them supple.

(iii.) The effect of the scar, when it has finally contracted, in the direction of limiting movements must be carefully considered, and that *position of the limb* adopted which will best prevent or counter-

act this contractile tendency. Thus a wound involving the gastrocnemius or soleus muscles will heal more quickly in the equinus position of the foot; the very act of healing will also pull the heel up into this position; but if it is permitted to develop, the subsequent limitation of the movement of the ankle will be so serious as to necessitate operative treatment at a later date; hence precautions should be taken during the healing of the wound to keep the foot at right angles to the leg.

(iv.) At the same time every effort must be taken to *prevent stiffness* or want of mobility of the parts liable to be affected by the cicatrizing process. Careful movement of all parts to be kept at rest for any length of time must be instituted with due regard to the conditions mentioned above, and no joint is ever unnecessarily immobilized. Especially is this warning needed as regards the smaller joints of the hands and fingers; it is seldom that the fingers or thumb need to be kept on a splint for wounds of the forearm, and the patient must be urged to exercise them in spite of the pain produced. A little persistent effort and determination will prevent much stiffness at a later date. Massage and movements of the portions of the limb not immobilized will assist considerably in maintaining and improving the nutrition of the limb, as well as in assisting the reparative activities of the part and improving the general health of the patient.

The question of **Amputation** will necessarily arise in dealing with the graver forms of lacerated wounds, although many limbs are now saved which would inevitably in former days have been sacrificed. Hard-and-fast rules cannot be laid down as to when to amputate and when not to do so; each case must be treated on its own merits. The following **general** points must first be carefully considered: (*a*) The *age* and *vitality* of the patient. An old person has less recuperative power than a young one, and hence a damaged limb may often be left in a youth which one would certainly remove in an elderly person. The vitality of the individual is perhaps even more important than the age, for some men at sixty are in a much more healthy and resistant state than others at forty. The habits, as to temperance, etc., must also be taken into consideration, and the existence of general diseases, such as diabetes or albuminuria, might induce one to resort to radical rather than conservative measures. (*b*) The vitality of the *extremity* injured. A leg has to be sacrificed more frequently than an arm, since the vitality and reparative power of the latter are so much greater. (*c*) The presence or not of *infection* is of the greatest significance, since, if infection can be prevented, the chances of preserving the limb are greatly improved.

The **local** conditions which suggest or determine the performance of an amputation, may be conveniently divided into two groups—viz., where amputation is essential, or where it is doubtful.

A. Amputation is certainly **called for**—

1. **To trim up the** stump of a limb torn off by machinery, or cut off by a railway train, or blown off in an explosion.

2. When the whole limb or one complete segment of it has been totally disorganized, or crushed to pulp, though still retaining its connection with the body.

3. In cases where gangrene is imminent or has supervened, especially if it is of the spreading type.

4. When severe infective symptoms develop in a case where an attempt is being made to save a limb, the retention of which was from the first doubtful, or when exhaustion supervenes from prolonged suppuration.

5. In severe compound lacerations of the foot *in old people*, involving the bones and laying open the common synovial cavity. Infection is likely to result in disease of the bones and joints, whilst the distance of the foot from the centre of the circulation increases the likelihood of gangrene.

B. **Amputation** is **doubtful** in the following conditions:

1. Compound comminuted fractures in parts other than the foot do not *per se* require amputation unless very extensive. By careful attention to antisepsis; free drainage, and the removal of detached fragments of bone and foreign bodies, which should usually be accomplished under an anæsthetic, limbs which would have formerly been condemned to amputation can not only be preserved, but also restored to a considerable degree of functional usefulness. The final decision will largely depend on the age, condition, and previous habits of the individual.

2. When the soft parts have borne the brunt of the injury, and have been extensively stripped from the bones—*e.g.*, when the muscles of the forearm have been torn up in a machine accident—amputation is by no means an essential, provided that they can be restored to their original position, that there is a reasonable probability of their vitality being maintained, and that the utility of the limb will not be hopelessly impaired, as a result of lesions to the nerves, after the wound has healed. The surgeon has here to balance carefully the risk run if an attempt is made to save the limb with the value that the limb if saved will be to the patient.

3. Laceration of the main artery of a limb need not in itself determine amputation; but if in addition to this the bones, veins, or nerves are hopelessly injured, and especially in the lower extremities of old people, amputation should be undertaken without delay.

III. **Punctured Wounds and Stabs.**—These may be brought about by any form of penetrating instrument, from a pin or needle to a sword, bayonet, or pickaxe. The external opening may be in itself insignificant, the chief danger arising from the damage to deep structures—bloodvessels or nerves being divided, and serous cavities or viscera opened, or even the skull penetrated. The subsequent symptoms depend almost entirely upon the question of infection; there is always considerable difficulty in draining effectively the depths of a long and narrow wound, and therefore collections of pus readily form and may burrow in all directions amongst the deeper planes of tissue opened up by the wound.

Wounds resulting from the modern sword-bayonet, though very

serious from their size and depth, are not so difficult to heal as those inflicted by the old triangular blade. They should be effectively purified, well drained, and the skin opening not allowed to close until all discharge has ceased; if necessary, a counter-opening is made at a dependent spot. Serious hæmorrhage or paralysis calls for immediate opening up of the wound, so as to expose and deal with injured vessels or nerves.

Needles are frequently broken off short in the body, especially in the hands, feet, knees, or nates. If seen soon after the injury, it is advisable to undertake their immediate removal, a proceeding sometimes very simple, but occasionally necessitating a deep and difficult dissection. Should the needle not be removed, it may travel about the body along the muscular and fascial planes, and there is no knowing where it may lodge or come to the surface, or how long it may remain in the body; it has been known to constitute the nucleus of a renal calculus.

One of the most troublesome and painful forms of penetrating wound is that caused by a **fish-hook,** since the barbed end catches in the tissues, and it is impossible to withdraw it without increasing the size of the wound considerably. The simplest plan of treatment is to push on the hook and make it protrude through the skin elsewhere to such an extent as to enable the barb to be cut away, when the remainder of the hook will be set free.

For the detection of penetrating foreign bodies of a metallic nature, or of splinters of glass or stone, radiography is indispensable. It is always necessary to take the radiograph from two directions, and if the antero-posterior one is taken stereoscopically, so much the better. Even with this assistance, it is often difficult to find a foreign body, such as a needle, and it is advisable to undertake the operation for its removal under the rays with the assistance of a screen. These are now made in a sterilizable form, so that full asepsis can be maintained.

IV. **Poisoned Wounds.**—The great majority of poisoned wounds are due to some definite micro-organism, and have been discussed elsewhere. A few only remain to be dealt with here.

Stings of Insects, such as bees and wasps, are exceedingly painful, but not dangerous, unless some local complication, such as erysipelas, supervenes, or the stings are very numerous, as when a swarm of angry bees settles on a person, or the part involved is such as to lead to serious swelling, as in the pharynx or tongue, œdema of the glottis possibly arising under such circumstances. All that is usually needed is the application of a weak alkaline lotion, whilst a common and efficient domestic remedy is a freshly sliced onion or a blue-bag applied to the part.

Some varieties of flies and spiders are also extremely virulent, and the former play an active part in the transmission of many types of disease. Thus various forms of infective cellulitis or lymphangitis may be caused by the bite of a fly that has been feeding on putrid carrion, whilst the epidemic diarrhœa of children in summer is largely due to the infection of their food by flies. The tsetse

fly in South and East Africa is the carrier of the virus of sleeping-sickness. Mosquitoes and midge bites are exceedingly irritating; one variety, the female of the Anopheles, is the active agent in transmitting the virus of malaria, and another is responsible for the development of filariasis. Fleas carry the *B. pestis* from infected rats to the human subject, giving rise to plague, and lice are responsible for transmitting typhus fever.

Chigoe, or the jigger, occurs in many parts of the tropics as a result of the activity of the sand-flea (*Pulex penetrans*). The female, when impregnated, fixes herself by the head to some portion of the skin, preferably of the sole of the foot, or under the nails, and proceeds to burrow between the dermis and the epidermis, producing thereby a peculiar stinging pain, which is very characteristic. The head remains fixed in the deeper part of the pocket, whilst the abdomen becomes greatly distended in the course of a few days, constituting a sac, containing a large number of eggs. Great irritation is caused thereby, and inflammatory phenomena, with perhaps swelling of lymphatic glands, especially if the sac is crushed or burst. Left to itself, the ova are set free, and escape externally to develop into vermiform larvæ. **Treatment** consists in enlarging the burrow by means of a blunt needle or probe, and digging out the jigger complete, taking care not to burst the sac. The small opening is touched with tincture of iodine, but if suppuration is present, fomentations will be required.

Snake-bites are exceedingly rare in this country, the common adder (*Pelias berus*) being the only venomous one likely to be met with, and even with this the poison is not sufficiently virulent to do much harm unless the individual attacked is a child or a person in a very bad state of health. The poison is conveyed to the wound from the glands and poison sac situated on either side of the upper jaw through fine canals in the specialized teeth, which open at their apices; these teeth are so delicate in some snakes that it may be difficult to find the wounds produced by them. The effects of an adder's bite are not, as a rule, noticed immediately, but come on in the course of an hour or so; extreme prostration supervenes, with a weak pulse, cold clammy perspiration, dilatation of the pupils, and perhaps delirium in bad cases, merging into coma.

The **Treatment** consists in preventing the absorption of the virus by tying a ligature firmly above the wound, which should then be laid open so as to allow of free bleeding, and the surface excised or cauterized. The collapse resulting from absorption of the poison is best remedied by the administration of stimulants or the hypodermic injection of strychnine.

In India and other countries many varieties of poisonous snakes are met with, and wounds are frequently fatal; indeed, in India it is stated that 12,000 individuals are yearly destroyed in this way. The symptoms come on rapidly, and are extremely severe, although they are modified according to the variety of snake. Treatment consists in the immediate application of a ligature round the limb above the wound, which is excised, or squeezed and sucked after incising, so as to encourage bleeding. The wound is then packed with crystals of permanganate of potash, or soaked in a concentrated solution of the same or of peroxide of hydrogen. If the patient survive, the ligature is removed from the limb after a few

hours. Strychnine and stimulants are required to counteract the depressing effects of the poison, and Calmette's antivenene, if obtainable, may also be employed; it consists of the blood-serum of a horse that has been immunized by the injection of gradually increasing doses of cobra venom. The dose required varies with the size of the snake—from 10 to 40 c.c. or more—and to be beneficial must be injected within an hour of the bite.

The **Anatomical Tubercle,** or **Butcher's Wart** (*Verruca necrogenica*), consists in a papillomatous development usually on the knuckles or wrists of those who are exposed to wounds either in the deadhouse or slaughter-house. It is in all probability a manifestation of tuberculous infection, and, indeed, resembles somewhat closely the appearance of lupus when it develops on the hands. Treatment consists in the application of a powerful caustic, whilst in bad cases it is necessary to scrape the surface before cauterizing.

Poisoned Wounds of the Fingers are not uncommon, arising from the infection of pricks, scratches, and abrasions, and sometimes giving rise to serious consequences, and especially when the patient's occupation brings his hands into contact with infective material. The dissecting-room used to be a fertile source of poisoned fingers, but the care now taken in the preparation of the cadaver has almost abolished this form of trouble.

Undoubtedly the most serious of these arise in the post-mortem room, and are very largely due to carelessness and over-confidence. They may follow knife-cuts, or needle-pricks, or scratches from the exposed ragged ends of the ribs, and the infection is usually due to the *Streptococcus hæmolyticus*. Too often no heed is given to the wound except a more or less casual wash after the post-mortem is over. In a day or two, however, the finger and arm may be swollen and painful, and the axilla may even be involved, whilst grave constitutional disturbance of a septicæmic character may cause death in a few days. Not a few promising young pathologists and surgeons have lost their lives in this way. **Treatment.**—It is essential in cases of this type that the most thorough precautions be taken at once, seeing that life itself is at stake. If practicable, the investigation or operation should be concluded by someone else, and the wound exposed and cared for. The parts are thoroughly cleansed with ether soap, etc., and bleeding encouraged; if need be, an elastic compress is placed around the arm so as to ensure abundant venous bleeding for two or three minutes. The finger is then immersed in tincture of iodine for five minutes, care being taken to ensure its admittance to all parts of the wound. A comfortable sterile dressing is applied, and the arm put to rest and kept quiet until the outcome is assured.*

Should infection occur, it may be limited to the nail matrix or pulp of the finger, or it may involve the tendon sheaths or palmar fascial interspaces, or in the worst cases it may become a rapidly spreading lymphangitis, running up the arm into the axilla in a few hours, and possibly flooding the system with germs. Most of these conditions

* See Handfield Jones, *Lancet*, March 13, 1926

are described elsewhere, as also the appropriate treatment, but it may be well to deal with the localized infections of the hand known as whitlow at this place.

Whitlow is the term applied popularly to an infected wound of a finger or hand which is extremely painful, and usually runs on to suppuration. It is sometimes limited to the finger, but not unfrequently spreads to the palm or even to the forearm along the tendons and their sheaths, or along the fascial spaces of the palm. Several varieties may be recognized, and it is most important that a clear diagnosis should be made before any treatment by operation is undertaken.

(*a*) The **Subcuticular** whitlow (or purulent blister) consists merely in the development beneath the cuticle of pus which separates it from the cutis vera. It is painful, but otherwise of little importance. A boric fomentation, preceded by the removal of the loose cuticle, is all that is needed in its treatment.

(*b*) Infection of the *cellular tissue* of the fingers is extremely liable to involve the underlying tendon sheaths, except when it is limited to the *terminal segment*, and in this paragraph that limited portion will be alone alluded to. Under these circumstances the end of the finger becomes bulbous and extremely tender, the swelling extending perhaps some way up the finger, but there is no painful limitation of flexion or extension. The swelling is at first hard and brawny, and even when pus is present it may be difficult to detect fluctuation unless the abscess is nearly pointing. Constitutional symptoms are not as a rule very severe, although the pain may exhaust the patient, being greatly increased by allowing the hand to hang down. **Treatment.**—In the early stages fomentations or poultices are desirable, together with elevation of the hand. Bier's method of inducing hyperæmia by the use of an elastic bandage around the arm is beneficial, and if the pressure is correctly adjusted will relieve pain. It may be applied for thirty to sixty minutes once or twice a day. When pus has formed an incision (Fig. 81) is made on one or both sides of the finger—never in the middle line—extending nearly to the distal crease, and perhaps joined by another running parallel to the edge of the nail and about a quarter of an inch from it. The whole of the pulp of the finger may by this means be opened up and drained by the introduction of a strip of rubber glove, and if, as sometimes happens, the terminal phalanx has necrosed, it can be removed safely and easily.

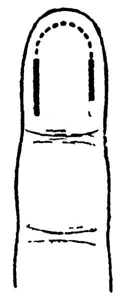


FIG. 81.—INCISIONS FOR WHITLOW LIMITED TO TERMINAL PHALANX.

The dotted extension is only employed in serious cases when it is probable that the bone is involved.

(*c*) The **Thecal** form of whitlow is in reality a suppurative tenosynovitis of the flexor sheaths, and the infection is very liable to

spread from them into the palm and even to the forearm. The arrangement of these sheaths is indicated in Fig. 82, and it will be obvious that the thumb and little finger are more likely to be affected in this way than the other fingers, and the thumb more often than the little finger, as there is a slight break in the continuity of the little finger sheath which, however, is readily overstepped. The sheaths of the index, middle, and ring fingers are liable to give way at their proximal end, and then an inflammatory affection of the palmar fascial spaces will subsequently develop, and this may in turn extend to the forearm under the annular ligament.

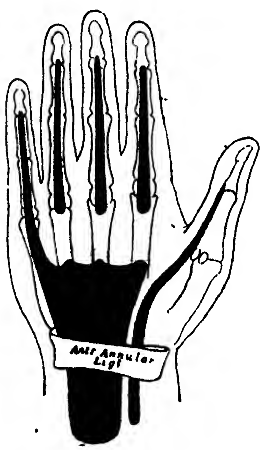


FIG. 82. — DIAGRAM OF TENDON SHEATHS OF FINGERS AND PALM.

In a whitlow of this type the finger becomes generally swollen, both in front and behind; it is slightly flexed, and the patient is quite unable to move it, because of the severe pain caused thereby; any attempt at extension is exquisitely painful, and acute tenderness is present over the whole course of the sheath. The swelling is at first of a brawny character, and even when pus is present fluctuation is rarely to be detected, except when it is actually pointing. Sometimes the pus points towards the dorsal aspect of the finger, owing to yielding of weak spots in the postero-lateral aspects of the sheath. The intercarpal articulations may be secondarily involved, and necrosis or caries of the phalanges may follow. There is always a good deal of febrile disturbance of a septic type, and want of sleep from the pain is distressing. Unless early relief of tension is given, the tendons are very likely to slough, or at best to contract such adhesions to the underlying bone or sheath as will render the finger useless.

Extension to the *palmar bursæ* in lesions of the thumb and little finger is indicated by the palm becoming swollen, although the tension of the palmar fascia prevents this from being marked. The part is very tender and the pain severe. Unless relief to tension is given early, the trouble is almost certain to spread under the anterior annular ligament to the forearm, and do much mischief. Sloughing of the tendons is very likely to follow, or crippling adhesions to form.

Extension to the *palmar fascial spaces* from the three middle fingers is indicated by much the same symptoms, and may be followed by very similar results. If the trouble spreads upwards to the forearm, it usually finds its way beneath the tendons, and thus appears in the arm between the pronator quadratus and the tendons of the flexor profundus. Thence it travels upwards in close proximity to the interosseous membrane along the median nerve or ulnar vessels.

Lymphatic infection may be associated with any of these manifestations in the form either of an acute lymphangitis or acute inflammation of the epicondyloid or axillary glands, in the latter instance being perhaps followed by an axillary cellulitis. Naturally the constitutional results will be greatly increased by these complications.

Treatment in the early stages consists of rest to the arm, which is supported, fomentations, and passive congestion. As soon as it is evident that pus is forming or has formed, operative measures must be undertaken in order to try and limit the mischief. Incisions on one or both sides of the finger are required to lay open the sheath (Fig. 83, A or B), and thereby to prevent as far as possible the formation of adhesions and to prevent sloughing. It may suffice to limit the incisions to the interarticular segments of the finger, but in bad cases the whole length of the sheath must be laid open (C).

In the case of the little finger, extension to the ulnar bursa may be suspected if there is acute tenderness along its course; and if after opening the sheath pressure in the palm causes a discharge of pus, this complication is assured. A director or bent probe is then passed up the sheath, and cut down on through an incision on the radial side of the hypothenar eminence (Fig. 83, D), and thus the sheath is again opened freely. No drainage-tube is permissible in these cases, as they only lead to sloughing. If it is necessary to keep the opening in the sheath patent, a strip of rubber glove possibly rolled into a spill must be used.

Similar treatment is required for infection of the palmar bursa, and the necessary incision is shown in Fig. 83, E.

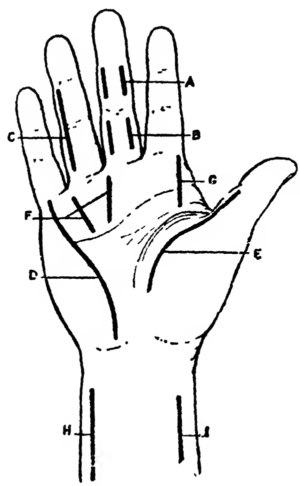


FIG 83.—INCISIONS FOR DEALING WITH VARIOUS FORMS OF WHITLOW AND THEIR EXTENSIONS TO HAND AND FOREARM.

A and B, for limited infections of phalanges; C, for thecal infection, D, for ulnar bursa; E, for palmar bursa; F and G, for palmar cellulitis; H and I, for extensions of infection to forearm.

Infection of the fascial spaces of the palm in whitlows of the middle three fingers is similarly dealt with by suitable incisions. The chief space lies in front of the metacarpal bones of these fingers, and can be reached by incisions extending from the centre of the web to midway between the distal and central flexion creases in the palm (Fig. 83, F). They are best placed on either side of the ring finger, and should extend down to the lumbrical muscle, along which a sinus forceps is introduced and passed upwards beneath the tendons. Drainage is maintained by a strip of rubber glove. Another space

exists on the thenar side of the middle metacarpal in front of the adductor transversus muscle; it can be reached for drainage purposes by an incision along the side of the index metacarpal (Fig. 83, G), which exposes the lower border of the adductor, and in front of this the sinus forceps can be introduced so as to reach the collection of pus.

It must be remembered that infections of the palm similar in type to the above may arise quite independently of whitlows as a result of direct infection through penetrating wounds.

If the mischief spreads under the annular ligament and suppuration occurs in the forearm, incisions are made on either side (Fig. 83, H and I), so as to enable a pair of sinus forceps to be passed down in front of the pronator quadratus, where the pus is likely to be found. Drainage is here maintained, as elsewhere, by a strip of rubber glove and not by a drainage-tube. The all-important element in the case is absolute freedom from tension by large incisions.

After the incisions have been made, fomentations are maintained as long as there is any appreciable discharge of pus. Baths are useful, and later packing with gauze soaked in flavine or other applications is desirable as a dressing. Passive congestion from time to time is useful; but when once sufficient drainage has been provided, and extension of the trouble is at an end, the patient's efforts must be directed to regaining movements of the fingers, and that in spite of the pain caused; radiant heat baths and diathermy will often be very beneficial in the later stages.

Repair of Wounds.

When any of the tissues or solid organs have been divided or injured, the reparative activities of the body early assert themselves in order to make good the defect, unless they are for a time diverted by the necessity of overcoming an invasion of bacteria, and even then the means employed by Nature to conquer the microbes are useful in determining the early stages of repair. It matters little what tissue of the body is involved, for the reparative process is the same in all, although modified somewhat by the local conditions. In the majority of cases the ultimate result is a production of cicatricial or scar tissue, which serves as the bond of union between the divided structures, and varies in amount with the closeness of approximation, the maintenance or not of rest to the part, and the degree of inflammatory disturbance in the wound.

In a few tissues a further stage—viz., that of *regeneration* of the injured parts—is reached; in this there is a preliminary formation of granulation tissue, which is subsequently invaded and replaced by a development from the parenchyma of the affected tissue or organ, but this can only occur when the parts are accurately brought together and perfect asepsis is present. Striped muscle, bone, tendon, nerves, and some glandular structures may thus be regenerated; the skin and subcutaneous tissues, rarely; the spinal cord, never.

The **general facts as to the process of repair** may be stated as follows: The margins of the wound are always bounded by an area of tissue in a state of lowered vitality, even if no bruising or sloughing of the parts is present. The divided vessels are in a condition of thrombosis as far as the next patent branches, which in their turn are slightly dilated, partly as a result of this obstruction and partly from the reflex irritation of the injury. The surface of the wound is generally covered with a film of lymph or blood-clot, whilst any spaces left in the interstices of the tissues are similarly occupied.

(*a*) The first stage in the process consists in an abundant *exudation of small round cells*, presumably leucocytes, whose function is to remove dead or damaged tissues, as well as to break up, disintegrate, and finally absorb, any blood-clot They are derived from the surrounding vessels, and are accompanied by a certain amount of plasma, so that the early manifestations of a slight inflammatory reaction are simulated, and this, if it does not exceed certain limits, is a beneficial proceeding If much tissue has to be absorbed, or when a foreign body such as a suture is buried, giant cells are likely to make their appearance. After their work is completed they disappear, either finding their way back into the circulation, or being destroyed by the fibroblasts.

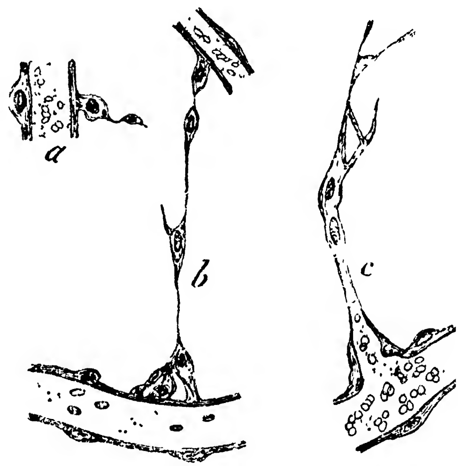


FIG. 84 —NEW VESSEL FORMATION.
a, A small bud-like projection from the wall of a capillary; *b*, the union of such buds one with another, *c*, the canalization of these processes.

(*b*) The exudation of leucocytes is soon followed by the appearance of a number of large oval cells with abundant protoplasm and large vesicular nuclei, known as *fibroblasts*. These cells are mainly derived from those composing the tissues of the part, either from the connective-tissue corpuscles or the endothelial cells lining the capillaries, lymphatics, or lymph-spaces. Whatever their origin, they soon form a layer of cellular tissue which lies upon the surface or between the lips of the wound, whilst the previously effused leucocytes disappear.

(*c*) The *vascularization* of this cellular layer forms the next stage in the process. This is brought about by the outgrowth from the walls of the nearest capillaries of solid rods of protoplasm (Fig. 84, *a*), which appear first as minute buds, but rapidly increase in length.

and may be single or double. They soon bend over to unite with similar threads growing out from other capillaries, or with the wall of another vessel (Fig 84, *b*), or occasionally they unite with the vessel from which they started. After a time these protoplasmic threads become canalized (Fig. 84, *c*), and a communication is established between them and the mother vessel, so that blood passes into them. The new capillary wall, at first homogeneous, soon becomes lined with definite endothelial cells, and strengthened by connective tissue derived from the fibroblasts around. By this means a soft vascular tissue is produced, known as *granulation tissue* (Fig. 85), consisting of loops of capillaries supported by large nucleated cells with a varying amount of intercellular substance, which becomes fibrillated in texture. The capillary loops arise in leashes from small terminal arterioles, and it is to this arrangement that the granular appearance of the developing tissue is due; each granulation, as it arises, is about the size of a pin's head.

FIG 85.—GRANULATION TISSUE FROM THE BASE OF AN ULCER (AFTER MACCALLUM)

The rounded outline of the granulation is clearly seen, and the longitudinal arrangement of the capillaries beneath the surface.

(*d*) The *transformation* of this granulation tissue into *fibro-cicatricial tissue* is next proceeded with. The fibroblasts become spindle-shaped, and finally long and narrow, with pointed extremities, which often branch; the nuclei also become long and narrow, and lose their vesicular appearance. Around them is developed a fibrillated structure of a collagenous material, which is finally transformed into the fibrous tissue of the scar; the actual arrangement of this material varies with the physical characters and condition of the wound. By the contraction of these fibres the fibroblastic cells become flattened out and compressed, and the newly-formed vessels constricted, so that as time passes the scar tissue becomes less and less vascular, and consequently firmer and denser, as well as smaller.

(*e*) Whilst this last stage is in progress, the surface of the wound is covered over with cuticle, which spreads inwards from healthy epithelium in the neighbourhood of the wound, and especially from the deeper layers of the rete Malpighii.

As already stated, the general process of repair sketched above is modified according to the character and condition of the wound. The following modifications are met with:

1. **Healing by First Intention,** or **Primary Union,** occurs in cleanly-cut aseptic wounds where the lips are unbruised and brought together, so that no extensive collection of blood or discharge between them is possible. A thin layer of blood-clot lies between the surfaces of the wound and penetrates into their irregularities, and the contraction of this clot is at first the chief means of keeping the deeper parts in apposition. There is but a microscopic line of damaged tissue, which, together with the blood-clot, is easily absorbed. A thin layer of granulations develops on either side (Fig. 86), and these unite across the wound in a few days and are transformed into granulation tissue.

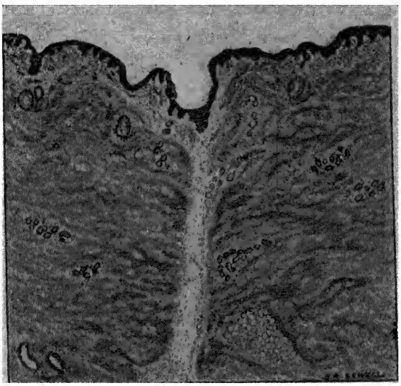


FIG 86 —HEALING OF WOUND BY FIRST INTENTION.

2. **Healing by Granulation,** or **Second Intention,** as it used to be termed, is met with (*a*) in cases where there has been definite loss of substance, so that the lips of the wound are not, or cannot be, approximated; as also (*b*) when the surface of the wound is bruised or damaged, so that portions of tissue have to separate by sloughing; or (*c*) when the advent of infection has prevented the occurrence of primary union.

When a small amount of aseptic dead tissue is present, it is removed by an invasion of leucocytes from the surrounding vessels, which disintegrate and gradually absorb it. These are followed by the fibroblasts, which form a layer of granulation tissue on the surface of the wound. If there is much slough to be dealt with, the vitality of the granulation tissue cannot be maintained beyond a certain distance from its source of nutrition, and so by a process of simple anæmic ulceration the unabsorbed dead portion is cast off and a granulating surface

remains. If bacteria are present in the slough, inflammation occurs in the adjacent living tissue, and this brings about a similar result, though accompanied by suppuration and fever.

When, however, there is a simple loss of substance, with no bruising or infection of the tissues, the course of events is as follows The blood-stream in the superficial capillaries having been arrested, adjacent vessels become dilated, and from these an exudation of plasma and leucocytes results. The plasma coagulates on the surface and forms a layer of fibrin, entangled in the meshes of which are a number of white corpuscles, so that the wound becomes covered with a film of whitish-yellow material known as lymph. This gradually increases in amount and thickness, and is vascularized from below into granulation tissue, this process occupying from four to seven days.

The healing of a granulating wound is brought about by the conversion of the granulations into fibro-cicatricial tissue, and by the surface becoming covered with cuticle. The contractile tendency inherent in all cicatricial tissue produces two results from its presence in the base of the wound beneath the superficial layer of granulations: (i.) The surface area of the wound is diminished in all directions, a most important element in the healing process, since if the base is adherent to some dense resisting structure repair is slow and difficult. When the granulating surface is very extensive, contraction may proceed to such a degree as to obliterate many of the vascular channels, and by thus depriving the superficial tissues of their adequate nutrition, the healing process may be indefinitely prolonged. (ii.) The depth of the wound is diminished, partly by the continuous growth of granulation tissue from below upwards, but mainly by the contractile base lifting the deeper structures to the surface. If the base of the wound cannot be raised, the superficial parts are drawn down, and the cicatrix is usually depressed and adherent to the underlying parts.

During the process of repair the wound takes on the appearances already described as characteristic of a healing ulcer (p. 108),

It is sometimes possible to hasten the healing of an extensive wound by drawing together the margins so that two granulating surfaces are brought into apposition. If the parts are clean, the granulations quickly bridge the gap. This **union of granulating surfaces** is often helpful in the closure of abdominal wounds left by the drainage of deep abscesses.

3. **Healing under a Scab** is a proceeding that can only take place in very small wounds, such as superficial grazes and abrasions, and is practically identical with the granulating process, except that, instead of an artificial dressing applied by the surgeon, the lesion is covered by a scab which consists of clotted blood or dried exudation. Should infection be present, pus is likely to accumulate beneath the scab and may cause trouble.

4. **Healing by Organisation of Blood-clot** can only be watched in strictly aseptic wounds where there is definite loss of substance, as

in the deep channels sometimes made in the treatment of bones thickened by chronic osteitis, but of course it occurs in all subcutaneous wounds where there is effusion of blood. The dark coagulum shows no trace of change for some days, but gradually the peripheral portions become granular and yellowish-white in colour; granulations appear in this peripheral portion, and in time spread through the whole mass from periphery to centre, and then repair occurs as described above. The clot is absolutely passive in this process, being infiltrated by leucocytes and removed by degrees, and thus merely serves as a basis of support or scaffolding for the building up of the granulation tissue which replaces it.

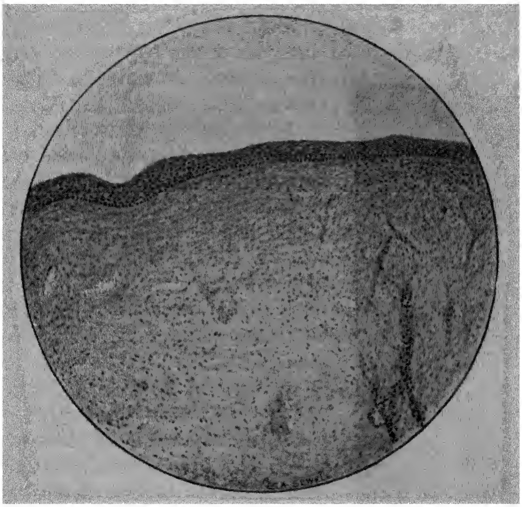


FIG. 87.—SCAR FROM A RECENTLY HEALED SUPERFICIAL WOUND. (LOW POWER.)

The epithelial surface is regular and devoid of papillæ; the scar tissue has an abundance of cells scattered through it, as well as some very obvious vessels, which will disappear almost entirely at a later date.

5. **Healing of a Detached Portion of the Body** is not unfrequently seen when parts of the nose, external ear, or finger-tip, are separated. The loose portion is carefully cleansed, reapplied accurately, and fixed firmly, though gently, into position. If it lives, union occurs by first intention; if it dies, but remains aseptic, it constitutes a cover or scab, under which healing by granulation occurs.

A Scar is a mass of fibroid tissue covered by epithelium, which has been formed in the repair of a wound (Fig. 87). It is at first vascular, and contains cells of the connective-tissue type; but after a time, as contraction continues, the cell elements become flattened

out, fewer in number and less obvious, the intercellular fibrous tissue more abundant, and the vessels constricted, so that finally a scar becomes well-nigh bloodless. Where superficial, its colour changes from red to white, and if of small size it may almost disappear, but never absolutely, unless the subcutaneous tissue has not been involved. When the parts around become injected by any cause, such as sharp friction, the anæmic scar tissue again becomes evident by contrast. Lymphatics, nerves, hairs, and cutaneous glands are all absent, except perhaps at the periphery, and the epithelial covering itself is merely a uniform layer without papillæ.

The **Pathological Phenomena** connected with scars are as follows:

1. **Excessive Contraction,** which may lead to great deformity, especially when the wound has occurred in the flexure of any of the joints. A web-like mass of fibroid tissue then forms, limiting movement, and requiring operative interference. A seriously burned hand may by cicatricial contraction be fused into an unsightly mass, rendering the fingers of little use; similarly, the chin may be drawn down and practically fixed to the sternum, and the lower lip everted, as the result of a burn on the front of the neck (Fig. 88). The *Treatment* of such conditions consists in dividing or excising the cicatrix, and thus freeing the parts, during which process it must be remembered that deeper structures of importance, such as the main vessels and nerves, may be adherent to the under surface, and thus be endangered. When once the scar has been divided, there is often no difficulty in restoring the parts to their normal positions, although when the contraction has existed for any length of time it may be advisable to do this slowly, even by gradual extension with a weight and pulley, so as to avoid the risk of lacerating the deeper parts, which are usually contracted secondarily. The raw surface thus produced is covered with epithelium by Thiersch's method or Wolfe grafts.

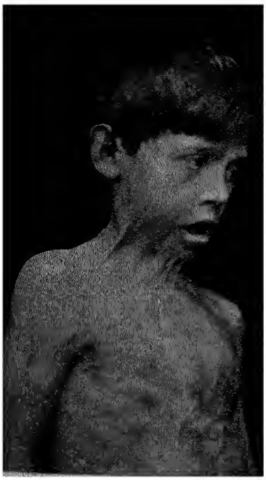


FIG. 88.—CICATRICIAL CONTRACTION OF NECK AND FACE AFTER A BURN

A similar process of contraction takes place in scars developing deeply amongst the tissues, or in connection with the viscera. Various deformities result from undue contraction after suppurative myositis, or after the intrinsic development of scar tissue in muscles, *e.g.*, torticollis (p 478), and this possibility must always be kept in mind during treatment. Grave disability may follow the healing of a wound opening up deep planes of tissue, unless precautions are

adopted to prevent subsequent contraction. Thus after clearing the axilla in operations for scirrhus mammæ, abduction is likely to be limited unless the arm is kept in a position of full abduction during healing. The contraction of scars in visceral lesions is also a matter of grave significance, and we shall allude later to various complications arising therefrom—*e.g.*, hour-glass stomach, stenosis of the pylorus, etc.

2. **Adherent scars** are often troublesome and painful, especially when the adhesions involve muscular tissues. Whenever the parts controlled by the affected muscles are moved, the scar is dragged on and pain results. Thus a scar involving the substance of the tibialis anticus and adherent to the overlying skin is dragged on in all movements of the foot, and walking may become difficult or impossible on account of the pain. In such cases the freeing of the scar from the skin may be desirable; the superficial portion of the scar is dissected out and the skin and subcutaneous tissues around are freed and drawn over the deeper part from either side. Scars adherent to bones are difficult to deal with and may be very crippling in their results—*e.g.*, when the quadriceps is firmly fixed to the front of the femur, the movements of the knee are gravely impaired. Massage and movements (active, passive, or forcible) may suffice to free the limb, but it is probable that operative treatment would be rarely justifiable.

3. **Overgrowth of the scar tissue** is sometimes met with, constituting what is known as the false or **Alibert's Keloid.** This most frequently occurs in the scars of burns or of wounds in tuberculous patients, but may arise from any cicatrix, presenting itself as a fibroid indurated mass of a dusky red colour, with perhaps a number of dilated vessels coursing over it, which occupies the region of the old scar, and may possibly send claw-like processes into neighbouring healthy structures. It consists merely of a hyperplasia of the scar tissue, but as to its ætiology nothing is known. With the exception of somewhat severe pruritus or itching, its presence entails no inconvenience, although if it occurs on exposed parts it may be very disfiguring. Removal is useless, since the keloid almost always recurs in the new cicatrix and in the stitch holes. After a longer or shorter interval it often disappears spontaneously. Exposure to X rays or to radium is beneficial in these cases, although the treatment may be of long duration.

4. **Ulceration of Scars** is usually an evidence of defective nutrition, or of local irritation. It is always chronic and difficult to heal. Local protection and stimulating applications, together with general tonic treatment, are required.

5. **Painful Scars** arise from either the implication of a nerve terminal in the cicatrix, or the pressure of a contracting scar upon the bulbous end of a divided nerve, as in amputation stumps. The pain is often very persistent and wearing, and may radiate widely. Treatment consists in freeing the nerve from the scar tissue (p. 410), or in its excision.

6. **Malignant Disease of Scars,** or of old chronic sores but partially healed, is of an epitheliomatous type, and appears as a hard ulcerated tumour with everted edges and a thickened base (*Marjolin's ulcer*). The progress is very slow, since the vascularity of the tissue is slight It is painless from the absence of nerves, and as long as the disease is limited to the scar no lymphatic implication will be noted. As soon, however, as the malignant growth invades healthy tissues, the usual phenomena show themselves. The diseased tissues, which are often very dirty and offensive at first, may be freely dissected out, having regard to subjacent structures, and the wound closed by some plastic method, or amputation may be required.

General Conditions connected with Wounds.

I. **Shock.**—By the term 'shock' is meant a condition of depression of the vital activities of the body associated with a marked and progressive fall of blood-pressure, resulting from injuries. It is very similar in type to the fainting fit which is caused by undue stimulation of the emotional centres, but is liable to be more prolonged, and indeed a prolonged faint may pass over into a condition of shock.

Local shock is a curious condition of insensibility to pain on handling which is sometimes present after severe injuries, and is especially seen after gunshot wounds; possibly it is due to some temporary paralysis of the sensory centres.

Shock may be described as primary or secondary according to its immediate or late relation in time with the causative lesion, and the former readily passes into the latter.

Primary shock is the immediate outcome of the accident or lesion, and the fall of blood-pressure and collapse associated therewith may often prove to be beneficial rather than harmful in that they are likely to limit hæmorrhage. It is probably caused to a large extent by a reflex inhibition of the heart's action through the cardio-inhibitory centre in the medulla. It is well known that if a frog's abdomen is opened and the exposed intestine sharply struck, the heart stops in a condition of diastole, whilst if the vagi are previously divided no effect is produced. Any severe peripheral injury may lead to such a result, especially those directed to the great sympathetic centres in the abdomen which are closely connected with the vital centres in the medulla. In this way sudden death may be produced by a severe blow in the epigastrium, or by drinking a glass of very cold water when heated; but as a rule this inhibition of the heart's action is never very prolonged in mammals.

It is also well known (owing to the work of Crile) that a marked fall of blood-pressure is caused by dividing or crushing a sensory or mixed nerve, and that clean division is less harmful than bruising or crushing. Cocainization of the nerve trunk before division or crushing blocks the central passage of the stimuli and protects the patient from the harmful influence of the nerve injury. It is obvious,

therefore, that the degree of primary shock must depend on the nature and character of the injury, as also on the abundance or not of the supply of sensory nerves to the part involved; organs like the testis, hand, and small intestine will be productive of much shock when injured. *Cæteris paribus*, deep wounds are more productive of shock than superficial, but a very extensive superficial lesion may be more harmful than a limited deep one; thus a scorch or superficial burn involving half the surface of the body is more productive of shock than the complete incineration of a hand or foot. Rough handling of organs, or clumsy bungling manipulation which results in dragging on or tearing across sensory nerves, is associated always with increased shock; the organs and tissues of the body should therefore always be treated by the surgeon with the utmost gentleness and delicacy.

The nervous susceptibility of the patient and the expectation or not of the injury are most important factors in the production of shock, for the more highly organized the nervous system, the greater is the amount of shock experienced, and *vice versâ*. When the whole nervous system is maintained in a state of tension, anxiously expecting the receipt of some painful impression, the effect produced will naturally be increased; whilst if the attention is diverted, and interest actively aroused in other things, the shock at the time is much diminished, though its effects may be subsequently greater. Thus, in the keen excitement and nervous tension of a battle, soldiers have often been wounded severely, and yet not known it at the time; whilst the pain of the most trifling cut may produce deep shock when the patient is in a state of dread and anticipation.

The **Symptoms** vary with the injury inflicted, from a slight momentary giddiness and faintness (closely simulating an attack of syncope or a fainting fit) to immediate and complete prostration insensibility, and even death. The pulse, at first small and weak, soon becomes irregular, extremely rapid, and often imperceptible; the countenance is pallid and shrunken, and the brow covered with cold sweat; the respirations are slow and shallow, whilst the temperature is usually subnormal.

After an interval, the length of which depends on the severity of the lesion and the treatment adopted, *reaction* occurs, being introduced by increased depth and frequency of the respirations; the pulse becomes slower and fuller, the surface warmer, whilst consciousness and muscular power are gradually restored. During this period it is not unusual for an attack of vomiting to supervene.

Sometimes reaction is accompanied by irritability, either of the mental or muscular systems, in the one case leading to traumatic delirium, which is always of grave import, and in the other to intense restlessness, as in the shock which follows extensive burns. It is probable that both these conditions are largely due to toxæmia. The term *erethitic* shock is sometimes applied to these manifestations.

Secondary shock is the condition into which an individual passes after sufficient time has elapsed for the primary shock to disappear, or which develops independently of it. Thus it occurs in the later stages of operations, especially abdominal, cranial or thoracic; it is seen after serious injuries, the immediate general effects of which have been slight; it is always aggravated, and its incidence favoured by loss of blood, exposure to cold, absence of food, fright, and other depressing factors, such as occur in withdrawing a wounded man from the fighting zone; it is also the outcome of grave infection of various types, and is practically identical with the condition of collapse which results from loss of fluid from the body, as in prolonged vomiting or persistent diarrhœa (*e.g.*, in acute cholera). Whilst primary shock tends to recovery, secondary shock establishes a vicious circle difficult to break.

The exact nature of this delayed shock has long been a matter of discussion, and there is still much uncertainty as to the exact explanation of the phenomena, and as to the part played therein by the various factors.

1. All observers admit that the most marked element present is the **diminution of blood-pressure.** Investigation with a mercurial manometer (*e.g.*, the Riva-Rocci instrument) places the average systolic pressure at 110-120 mm. of Hg. for normal soldiers, and the average diastolic pressure at 70-80 mm. of Hg. The immediate effects of wounds on the blood-pressure may be in two directions—viz., to raise the systolic pressure (*e g* , to 150-160 mm.), or to depress it even as low as 40-50 mm. In the former case, shock is absent, and rest and quiet in bed usually lead to a gradual fall of blood-pressure and recovery. In the latter, if the lesion is slight and no complication arises, the patient will recover when he is placed quietly in a warm bed, his blood-pressure rising gradually; if, however, the lesion is severe, or hæmorrhage occurs, or the patient is exposed to cold or rough transport causing pain, or is exposed to shell-fire, thereby introducing the element of fright, then the blood-pressure continues to fall, and if this continues the patient's condition becomes dangerous. Curious anomalies occur in some of the observations which cannot at present be explained. Thus head injuries with fractures of the cranium, but with the dura mater intact, are associated with a high blood-pressure, as also penetrating wounds with the ventricles involved; but when the cortex is torn without damage to the ventricles, and especially if a foreign body is retained, the pressure is low. Marked instability of the blood-pressure is also a feature of head injuries in the early stage, and it is desirable if possible to delay operation for a time until the pressure has become stable, as even with a high pressure operation may determine a sudden and rapid fall which ends in death. In abdominal wounds the blood-pressure is usually low to commence with, but may rise as the effect of rest and warmth begins to tell, only to fall again should acute peritonitis supervene. Penetrating wounds of solid viscera, such as the liver, are often associated with a rise of blood-pressure unless there is grave hæmorrhage.

2. The **reduction of the blood-volume** by withdrawal of fluid from the general circulation has long been recognized as one of the elements present in shock (Malcolm), and formerly this was supposed to be due to a generalized contraction of the peripheral arterioles and to engorgement and concentration of blood in the vessels of the splanchnic area. The latter suggestion has been proved on operation to be quite incorrect, and it is clear that the only feasible explanation of the loss of circulating blood fluid is that it has been retained in the capillary area. At the same time loss of fluid from the body by hæmorrhage, perspiration, etc., and the inability to take food assist in producing increased viscosity of the blood.

3. The **character of the blood** itself is altered in shock. The most marked feature is the high red count in the capillaries as compared with that in the veins, and the discrepancy is the greater as the shock becomes deeper; thus in a severe case there may be a difference of two million red corpuscles between the blood taken from veins and capillaries respectively. At the same time, apart from hæmorrhage, the hæmoglobin content remains unaltered. It is obvious that the blood in the periphery is more concentrated than in the centre of the circulation, and therefore more viscid; hence the peripheral circulation is less satisfactory. This blood concentration is only gradually recovered from, and may take four or five days to disappear; increasing dilution of the blood, as indicated by a fall in the number of the red cells, is a good sign up to a certain point; if it is still progressive after four or five days, it may be a danger signal of the advent of a generalized infection.

4. This concentration of the blood in the peripheral vessels, or **capillary stasis**, rendering the blood more viscid, is to a large extent due to the lowered blood-pressure, and it has serious effects. One of the most important is the diminished oxygenation of the tissues, which in turn results in ineffective metabolism and the production of toxic substances, together with a certain degree of acidosis, in the early stages due to a reduction of the alkali reserve in the blood, but in the later to an increase in the H-ion concentration. Moreover, the physiological activity of excretory glands, such as the kidneys, is checked, and this hinders elimination of toxic substances. That secondary shock is largely dependent on the **absorption of a toxic product,** especially if serious muscular lesions are present, is more than probable, and indeed such a substance has been isolated, and is known as *histamine*. 'When injected into anæsthetized animals, it produces arterial constriction with fall of arterial blood-pressure and concentration of the blood by loss of plasma. The output of the heart failed because the return of blood to it was inadequate' (Dale)

Experiments have shown that by crushing the thigh muscles of cats some substance is absorbed which produces shock, since massage of the injured parts hastens its appearance, whilst section of the spinal cord above the origin of the limb nerves did not prevent its appearance, and clamping of the vessels to the affected parts did so.

It is probable, therefore, that one of the most important elements in the production of secondary shock is the absorption of some product of tissue disintegration which causes a general dilatation of the capillaries, and later a morbid permeability of the same, so that a marked reduction of the volume of circulating blood, even to 50 or 60 per cent. of the normal (Robertson and Keith), follows. Cold, hunger, exposure, fright, etc., all combine to exaggerate this effect, and possibly in the absence of muscular lesions may be able to initiate it; but there is still a good deal to learn about this subject, especially as to its origin in civilian cases where grave muscular lesions are not present.

The **Symptoms** of secondary wound shock correspond practically to those of the later stages of primary shock mentioned above. The patient lies in bed in a condition of apathetic torpor, from which he is aroused with difficulty, but if so, he can answer intelligently, though faintly; the surface of the body is cold and pallid, and often covered with a cold clammy sweat; the temperature is subnormal and gradually falls; the pulse is weak, running, and perhaps uncountably quick; the eyes are sunken; the finger-tips, the lips, and the extremities of the nose and ears, gradually become blue and livid; the respirations are rapid and shallow, becoming irregular; the mouth is parched, and the patient complains of intense thirst. Gradually he passes into a state of complete unconsciousness and dies of respiratory failure. On post-mortem examination nothing peculiar is found, except the evidences of a generalized anæmia.

Diagnosis.—1. From the general results of **hæmorrhage.** Restlessness and thirst are then prominent signs, together with a sense of dyspnœa, causing rapid respiratory efforts; the mental condition, moreover, is less affected, and the patient is generally sensible; the surface is exceedingly blanched, and the pulse may have a marked hæmorrhagic wave. Moreover, in hæmorrhage the capillary blood-count is much lower than in shock, and that in the veins is still lower, since shock is usually present to some extent. The colour index of the blood, moreover, in shock is approximately normal, but in hæmorrhage is subnormal.

2. **In concussion of the brain** there are superadded to the symptoms of shock those more particularly connected with the region affected—*i.e.*, the intellectual centres—so that unconsciousness is the predominant feature.

3. When vomiting is approaching under the influence of an anæsthetic, the patient's pulse usually becomes weak and rapid, and the countenance pale. This condition closely simulates shock, and is often distinguished from it only by the progress of the case. Under such circumstances, if vomiting is plainly imminent, it is sometimes wise to increase the amount of anæsthetic, as the patient is usually not fully under its influence.

Treatment.—In slight cases of primary shock very little is needed beyond resting quietly for a few minutes, or the exhibition of some aromatic stimulant to the nostrils, such as ammonia or smelling-salts. In moderate cases the patient is also wrapped up and kept warm, and some warm drink administered. In more serious cases the patient is laid recumbent with the head low, and every precaution taken to guard against the loss of bodily heat during the necessary examination to determine the nature of the lesion. Temporary measures are employed to check hæmorrhage, if its permanent arrest by ligature of a spouting vessel cannot be immediately undertaken. Steps are then taken to warm the patient effectively and to provide him with warm fluid. In civilian work he is placed on a bed or couch with the head low, surrounded by warm blankets, and if need be hot-water bottles (suitably protected) are packed around him. A very simple, but successful plan of raising the bodily temperature is to place under the bedclothes, which are supported on a cradle, one or more electric lamps of such strength as to bring the temperature of the air around the body to 100° to 105° F. This has proved of much value in combating the severe shock following burns in children. Pain, if excessive, is relieved by the use of morphia; a ¼-grain tabloid placed in the mouth is a useful method of administration. If the patient is sufficiently conscious, he may be given a drink of hot weak tea with a teaspoonful of bicarbonate of soda added; if unconscious, fluid may be administered by rectum (if empty) in the form of hot coffee (5 oz.), normal salt solution (0·9 per cent.), or bicarbonate of soda (ʒi. ad ℥i.).

Operation has sometimes to be undertaken at once as a life-saving measure, but it is not infrequently possible to delay it for an hour

or two, so as to give the patient a chance of resuscitation by these means; in many abdominal conditions—*e.g.*, perforated ulcers of stomach or duodenum—a delay up to six or eight hours does not appear to affect the results very unfavourably, though naturally earlier operations mean less soiling of the peritoneum. The surgeon's judgment must be carefully exercised in balancing the dangers of shock against the risks of extending peritonitis. On the other hand, the condition of shock is sometimes aggravated by the pain arising from the damaged organ, or by absorption of toxins from a crushed limb, and then immediate operation may be justifiable, the pulse improving under the influence of the anæsthetic, or as the blocking influence of a spinal analgesic makes itself felt.

In all cases of operation during or immediately after shock, or in grave cases where shock may be anticipated, the most careful precautions must be taken to protect the patient from the various contributing causes indicated above.

(i.) The patient should not be unduly purged or starved beforehand, and a cup of hot tea or bovril two hours before the operation may often be administered with advantage, or a beef-tea or coffee enema half an hour previously. In nervous patients a small hypodermic injection of morphia (gr. $\frac{1}{8}$ or $\frac{1}{4}$) is desirable, combined with atropin (gr. $\frac{1}{100}$ or $\frac{1}{150}$) if ether is to be administered.

(ii.) The bodily heat must be conserved by suitable clothing and by avoiding exposure of the limbs or of more of the abdomen than is possible. The temperature of the operating room should not be below 70° F. Rapidity of execution, conformable with gentle handling and effective exact work, must be aimed at.

(iii.) Blocking of centripetal nerves is desirable, if practicable; spinal analgesia will sometimes protect the cardio-inhibitory and other medullary centres.

(iv.) If a general anæsthetic is required, chloroform must be avoided, and either gas and oxygen employed, or warmed ether administered by Shipway's apparatus.

(v.) Where there is any suspicion that acidosis exists, the patient should previously be given an alkaline drink, or an infusion of alkaline fluid. This is especially required in cases of gas-gangrene and in all cases of diabetes, where it is desirable so to saturate the patient with alkali that his urine becomes alkaline in reaction.

(vi.) The patient must be provided with an abundance of fluid so as to reduce the viscosity of the blood. The incidence of shock may often be prevented by commencing intravenous infusion before the operation begins and continuing it slowly throughout.

Formerly normal salt solution (0·9 per cent.) was used for infusion, but its influence in bad cases is so transitory that little reliance can be placed upon it. Hypertonic salt solution (2½ or 3 per cent.) gives better results. Professor Bayliss* has suggested the use of a colloidal substance which remains in the bloodvessels and exercises osmotic pressure; and of the various colloids available, gum arabic

* Bayliss, *Brit. Med. Journ.*, May 18, 1918.

is the most satisfactory. He advises that a 6 per cent. solution in normal saline is the best to employ, 'and tap-water may be used. The solution must be filtered through flannel or other convenient medium and then sterilized.' A pint of this fluid at a temperature of 118° F. in the receiver is slowly administered, not more than an ounce being given in each minute. The effect is to produce a rise of blood-pressure which in favourable cases persists. If it is thought desirable to add alkali, this may be given by mouth or by rectum. The best results are obtained in cases of hæmorrhage, but shock from other causes is beneficially influenced.

The actual transfusion of blood is also useful and helpful in cases of shock, but it should be followed after a short interval by an infusion of bicarbonate of soda solution.

After operation, treatment is conducted along exactly similar lines. Occasionally a subcutaneous dose of pituitrin is advantageous, but in bad cases its influence is very temporary. Strychnine and alcohol are similarly of little use, but hot black coffee given by rectum is decidedly beneficial, especially if followed by a continuous rectal infusion of saline.

II. **Traumatic Delirium.**—Although delirium is merely a symptom, it is occasionally of so pronounced a character as to demand special attention. Three forms are described:

(*a*) The **Active Delirium** which accompanies severe injuries, particularly in plethoric, and often in previously healthy individuals, whose environment has been suddenly changed from that of every-day life to a sick-bed in a hospital ward. Infection of the wound is usually present, and the delirium runs a course parallel with the fever. It is not usually of a violent type, although the patient may be irrational and restless; he moves the injured part without any evident appreciation of the pain which, if conscious, he must suffer, but he is easily restrained by the exhibition of firmness and tact on the part of the attendant. The symptoms are most marked at night, and commence at the end of forty-eight hours, lasting, as a rule, for two or hree days. There is a distaste for food, which, however, can be overcome by gentle persuasion.

Treatment.—Patients in this condition must never be left; the diet should be light, but nourishing; the bowels are thoroughly opened, and an icebag to the head may be useful. The wound should be freed from any purulent accumulation.

(*b*) **Delirium of a Low Muttering Type** is met with in individuals of low vitality, exhausted by dissipation, drink, disease, or faulty hygienic surroundings. It is commonly associated with fever of an asthenic type, such as is seen towards the end of infective diseases. The patient usually lies on his back, staring vacantly upwards, is incoherent, takes no notice of surrounding objects, and is observed to pick at the bedclothes and mutter to himself unintelligibly. There is often, in addition, an involuntary escape of urine or fæces. The mouth is generally open, the tongue dry, brown and cracked, and viscid mucus collects about the teeth (*sordes*).

The **Treatment** should be directed to careful nursing and feeding, as by that means alone can the patient be saved.

(*c*) **Delirium Tremens** is observed in individuals who, previously of intemperate habits, have suffered some serious injury, such as a compound fracture. The violent symptoms do not set in till about the third day, but are usually preceded by some amount of sleeplessness and wandering at night, or the patient may have short snatches of sleep, from which he awakes semi-delirious. This gradually increases, and is followed by violent delirium, in which the patient is haunted by terrifying visions of reptiles, horrible insects, and the like, from which he tries in vain to escape. During this stage of excitement he is with difficulty restrained from jumping out of bed; in many instances these patients are remarkably cunning, and, managing to elude the vigilance of their attendants, will succeed in escaping from the room by the door or window, and may inflict serious, and even fatal, injuries upon themselves or others. There is always a tremulous condition of the extremities and of the tongue, which is white and coated, whilst the bowels are obstinately confined. The pulse and temperature vary considerably, and the skin is often moist and clammy. The violent stage is always followed by profound exhaustion, in which the patient may gradually sink into a state of coma and die. In the case of a fractured leg, the struggles of the patient will cause considerable displacement of the limb, and necessitate constant attention to prevent further mischief. The limb should never be fixed to the bed, but slung in a Thomas's splint or Salter's swing, or immobilized in plaster of Paris.

Treatment.—In cases where an attack of delirium tremens is considered imminent, either from the previous history of the patient, the tremulous state of his hands and tongue, or his sleeplessness, the best treatment to adopt is to support the strength by suitable easily digested food, combined with free purging and, if need be, soporifics, such as chloral, bromide, paraldehyde, or morphia. Paraldehyde is perhaps the safest, whilst morphia must be administered cautiously; under such a regimen the symptoms usually soon disappear. In the acute maniacal attacks the patient must be fully controlled and guarded, but with as little manifestation of restraint as possible; failing other drugs, hyoscin in doses of $\frac{1}{200}$ to $\frac{1}{100}$ grain will sometimes succeed in quieting the patient, but must be used with great care, as it is a severe depressant. Nourishing food of a fluid type should be administered during the quiet intervals, and free purging is of course essential. The patient usually recovers from a first attack, but in the later ones may die of heart failure or exhaustion.

CHAPTER X.

THE GENERAL TECHNIQUE OF OPERATIVE SURGERY.

No one who has been brought up in the modern school of antiseptic or aseptic surgery can have any idea of the horrors that were perpetrated under the name of surgery by our ancestors. Anæsthesia was unknown, and perhaps this was an advantage rather than otherwise, as it limited the number and the scope of operations. Patients had to be forcibly restrained during the procedure; hæmostatic forceps were not in existence, and the operating theatre was not the quietly decorous spot that it now is, but rather resembled the shambles. The wards were a hotbed of surgical fever, and erysipelas, pyæmia, and other manifestations of pyogenic infection led to an appalling post-operative death-rate. Hospital gangrene, wound phagedena, and other affections now happily extinct, were common enough, and not unfrequently wards had to be entirely closed in order to limit the ravages of such diseases. The almost synchronous discovery of anæsthesia and antisepsis has transformed surgery, and from being an art dangerous, barbarous, and almost repulsive, it has been changed into a scientific procedure, beautiful in its details and beneficial in its results. In this connection the names of Simpson, who fought the battle of anæsthesia, of Spencer Wells, who popularized the use of hæmostatic forceps, and of Lister, who first applied to surgery the principles that were being taught by Pasteur as to the microbic origin of disease, will ever stand out as three of the greatest benefactors of the human race.

The **Antiseptic** plan of treating wounds, as originally introduced by Lord Lister, is an outcome of the germ theory of putrefaction. It has for its object the prevention of bacterial development in wounds by the use of *chemical agents*, some of which are true germicides, capable of destroying the bacteria, whilst others merely prevent or inhibit their growth.

Carbolic Acid, the first antiseptic employed by Lister, has a direct germicidal action in strong solutions, and an inhibitory effect in weaker ones. The crystals, when heated with 10 per cent. of water, constitute an oily fluid known as pure or liquefied carbolic acid, which is a powerful though superficial caustic, and may be applied without much fear to infected living tissues. Excess of the acid may be washed away with absolute alcohol, which quickly dissolves it. The liquid carbolic dissolves in water on the application of warmth, and the 1 in 20 and 1 in 40 solutions are those mainly employed;

the former is an efficient and potent antiseptic, but must be used carefully on delicate skins. It is most important to ensure the complete solution of the acid, as otherwise globules of it may be deposited on the hands or in the wound, and may do much harm. General absorption of this reagent leads to darkening of the urine, which may become olive-green or even black in colour, and this carboluria is often associated with giddiness, nausea, and vomiting, in bad cases progressing to a condition of collapse; diseased kidneys may be seriously affected. Weaker solutions are more readily absorbed than the liquefied or pure acid. It must be remembered that children and some adults are peculiarly susceptible to its action, and its application to large wounded surfaces, *e.g.*, burns, is inadvisable. On the other hand, its great affinity for all greasy and oily substances renders it a valuable antiseptic for emergency work, as it penetrates into the skin more readily than other agents.

Corrosive Sublimate is usually employed in solutions of 1 in 2,000, 1 in 1,000, or 1 in 500. Occasionally the last of these three solutions has 5 per cent. of carbolic acid added to it, constituting what is known as Lister's *strong mixture*. Sublimate solutions are inhibitory in action rather than germicidal, but are potent and reliable, especially in purifying the skin, when mixed with albuminous fluids, such as blood, an insoluble albuminate of mercury forms, which is ineffective as an antiseptic If, however, a dressing soaked in a sublimate solution (1 in 2,000) is kept for long in contact with the skin, it acts as a direct irritant, and may lead to an abundant formation of pustules, owing to the activity of the germs in the deeper parts of the cutis which have not been destroyed by the antiseptic. Instruments should not be placed in sublimate solutions, as, even if plated, they soon lose their bright appearance. It must be remembered that individuals very sensitive to the action of mercury may be salivated by this agent, and especially when used frequently for irrigating cavities to which a free exit is not provided. Symptoms of acute intestinal irritation, cramps, vomiting, and blood-stained diarrhœa may also be caused.

Biniodide of Mercury is a potent antiseptic, which has been chiefly employed in the form of a 1 in 500 solution in 70 per cent. methylated spirit for the purification of the hands or of the skin of the patient. It is, of course, extremely toxic. A 1 in 2,000 aqueous solution is also employed for the hands, and is less harmful to instruments than the perchloride.

Boric Acid is a mild and weak antiseptic, which may be utilized when stronger remedies might prove harmful—*e.g.*, in plastic operations and for infants It is also useful when antiseptic fomentations are required in treating inflammatory phenomena, and in ophthalmic surgery.

Iodine is a most valuable antiseptic, and at the present time is largely employed to sterilize the skin before operations in alcoholic solutions, varying from 2 to 5 per cent. To be effective, it is essential that the skin be previously freed from moisture or grease, and therefore in emergency cases it should be previously washed over with ether or acetone.

Iodoform is a yellow powder of characteristic and unpleasant odour, which probably acts by being decomposed in the tissues and slowly giving off iodine. Commercial iodoform is usually contaminated with a variety of germs; it is therefore wise to wash the iodoform before use in 1 in 20 carbolic lotion. Its chief value is in foul or tuberculous wounds, and, indeed, it seems to have a specific inhibitory action upon the development of the *B. tuberculosis*. It may be suspended in glycerine (10 per cent.), and after sterilization by immersing the vessel in which it is contained in boiling water for half an hour, this can be injected into tuberculous tissues, joints, or abscesses; or if open wounds exist, gauze soaked in this emulsion, as it is incorrectly termed, may be packed into them with advantage. Toxic effects of very variable type may follow from undue absorption of the drug. Gastro-intestinal disturbances, vomiting, diarrhœa, colic, etc , may be the chief symptoms, but delirium and collapse often supervene. There is always an abundance of iodine in the urine. Iodoform is an important constituent of the paste termed B.I.P.P (p 90).

Lysol (or one of the many British substitutes for it) is another useful anti-

septic derivative of coal-tar. It is freely soluble in water, and as a 2 per cent. solution may be used in syringing out cavities, such as the vagina, external ear, etc. Its solution is somewhat soapy, and tends to cling to the tissues and prolong its action.

Permanganate of Potash, Sanitas, and **Peroxide of Hydrogen,** all act in the same way as oxidizing agents; they are necessarily unstable, and cannot be utilized for dressings, and are therefore chiefly employed in the disinfection of cavities or wounds already contaminated. The most potent of these is peroxide of hydrogen, which is sold as a fluid capable of setting free 10 to 20 times its volume of nascent oxygen. It is quite unirritating, and may be poured directly into an infected wound, or even into the peritoneal cavity; forthwith it commences to effervesce, liberating its oxygen, and forming a frothy foam, which is likely to bring to the surface any loose sloughs or foreign bodies. Its use is particularly indicated in the treatment of dirty ulcers, carbuncles, sloughy abscess cavities, and the like.

Hypochlorous acid and the **hypochlorites** have been much employed recently in the treatment of infected wounds, and undoubtedly have great antiseptic power *in vitro*. They are derived from bleaching powder or chloride of lime, and the chief forms in which they are used are as follows:

Eusol is prepared by the action of boric acid on bleaching powder in the presence of water, and contains about 5 per cent. of hypochlorous acid. If kept cool and in the dark, it retains its antiseptic power for three or four weeks, but rapidly loses it in contact with living tissues or on warming, and hence must be used cold. It may be employed as a lotion to irrigate wounds, or may be applied directly on gauze as a compress, or even as a substitute for Dakin's solution in the Carrel treatment. It is, however, strongly alkaline, and when once the wound is clean, its prolonged application is harmful and hinders healing.

Dakin's solution (or rather Daufresne's modification thereof) is free from caustic alkali, and contains from 0·45 to 0·50 per cent. of hypochlorite of soda; if a smaller percentage of hypochlorite is present, the solution is inefficient; if more than 0·50 per cent. is present, it is irritating. The preparation requires much care, and inasmuch as bleaching powder is not of a uniform strength, its chlorine content varying from 20 to 37 per cent., it ought always to be tested first, and the amount of carbonate and bicarbonate of soda is regulated by this, the higher percentage of chlorine requiring more alkali; the finished product is again tested to ensure its accord with the standard indicated above

Dakin's solution must be kept in a cool place and in the dark, as it readily decomposes, and therefore it must always be used freshly made. It may be employed as a lotion for irrigation purposes, or gauze may be soaked in it and applied directly to wounds; it has been largely and beneficially utilized in the so-called Carrel-Dakin treatment of infected wounds (p. 88).

Chloramine-T is a stable hypochlorite compound which retains all the advantages of the above solutions. It is readily soluble in water at ordinary temperatures, and a 2 per cent. solution is generally advised for wounds. It may also be employed in the form of an ointment (10 per cent.), or to infiltrate gauze (5 per cent.). As a lotion it may be applied not only for irrigation purposes, but also to wet gauze for packing wounds, and for washing out mouth, nose, throat, or vagina.

Dichloramine-T is even more effective as an antiseptic, but is a less stable compound. It is best dissolved without heat in chlorinated eucalyptol (1 gramme in 10 c.c.), and when solution is complete 10 c c. of chlorinated paraffin are added. Septic wounds or cavities should be sprayed with this, or they may be packed with gauze strips soaked in it. The solution does not remain effective for more than three days. It is useful for nasal and buccal work.

Various products of **aniline dyes** have long been known to possess considerable antiseptic powers.

Brilliant Green (a triphenylmethane compound) is an antiseptic inactivated by blood-serum, and hence must be frequently renewed in an infected wound, if it is to be destructive of bacterial activity. In a 1 in 1,000 solution it is

harmless to phagocytosis and unirritating; it may be used by Carrel's method instead of Dakin's solution, or strips of gauze soaked in it may be packed into wounds. Tissues of poor vascularity are stained by it, but if the blood-supply is good this does not occur. Granulation tissue forms well and early when this antiseptic is applied.

Flavine is the most noted of these compounds (possibly because the most noisily exploited). It occurs in two forms, the original acriflavine (diamino-methyl acridinium chloride) and proflavine; these are practically similar in their appearance and in their antiseptic qualities, and may be used in a 1 in 1,000 watery solution, gauze soaked in this being packed into the wound. For its use in the treatment of wounds see p. 91.

The **Aseptic Method** of treating wounds consists in the elimination of chemical antiseptics as far as possible, and the substitution of heat, dry or moist, as a sterilizing agent. Every efficient antiseptic is more or less toxic and irritating, and there can be no question that from an ideal standpoint, the less they are introduced into wounds, the better. No more satisfactory germicide can be imagined than heat, in the form either of boiling water or of steam under pressure, and it is claimed that if everything brought in contact with the wound is aseptic, then no antiseptics need be employed. Dressings, swabs, towels, aprons or coats, and caps, are sterilized in drums or kettles by means of steam at ordinary pressure, or by superheated steam at high pressure. The latter, of course, is the more satisfactory, owing to its greater penetrative power, but the former can be effective if the drums are so constructed as to permit a free passage of steam through the articles to be sterilized, and if the latter are packed loosely and not tightly. The drum is first lined with a layer of lint or gauze, and a similar covering must be placed over the contents beneath the lid. A sliding shutter, or some suitable contrivance, allows the entrance of steam into the drum. When the drum is removed from the sterilizer, this shutter is closed, and the contents may be expected to remain sterile for a day or two, but not for long unless hermetically sealed.

For large hospitals an extensive and expensive sterilizing plant has to be installed, and probably some variety of the Washington-Lyon sterilizer is the best. Gowns, caps, and towels are usually dealt with in drums, but dressings and swabs are treated separately in packets wrapped in two layers of towelling, and for ward dressings two or three towels are added to these. The absence of antiseptics lays a heavy responsibility on those whose duty it is to prepare these materials, and all practicable foolproof checks should be utilized to avoid mistakes. Sterilizers, like all other machines, can get out of order, and it is quite possible for the process to be conducted without any steam reaching the contents. The danger of unsterilized packets getting mixed with the sterilized must also be provided for, as also of sterilized packets becoming subsequently contaminated. A recording steam gauge should always be connected with the inner chamber of the sterilizer, and each packet of dressing should contain a slip of paper with the date of preparation written thereon in an ink which changes colour only when effectively exposed to heat. An indelible

silver ink which writes red, and is turned black on exposure to heat, and runs in the paper with moisture, is suitable for this purpose, and can be obtained.

For small establishments a Schimmelbusch's low-pressure dressing sterilizer or a small high-pressure (5 to 15 pounds) steam sterilizer answers excellently. For private practice supplies of effectively sterilized articles in hermetically sealed tins or drums can now be obtained from many instrument makers and chemists.

Of course, there are two elements in an operation which can never be sterilized apart from chemical antiseptics—viz., the skin of the patient, and the surgeon's and assistants' hands—and thus the most complete aseptic precautions can never entirely eliminate chemical agents.

The **actual details of operative technique** vary somewhat with different surgeons, but the main principles which govern modern operative surgery are much the same in all, and the following sketch of the preparations required and of the routine usually practised in undertaking an operation may be considered more or less typical of modern methods:

1. **The Operating Room.**—The arrangement of this necessarily depends upon considerations of space and finance. It should not be unnecessarily large, and the old-fashioned 'theatre' with tiers of seats overlooking the central area is not desirable. Onlookers should have a low gallery provided for them, but little raised above the floor-space and shut off from it not merely by a rail, but by an effective barrier breast-high. It may with advantage be placed between the operating area and the source of light, but clear of the window, or to one side, and should be entered by a separate passage A north light is desirable, and it should come, not from the top, but from the side, in the form of what is known as a 'studio light.' The walls should be free from ledges on which dust may accumulate, and lined with white tiles or glazed bricks, or, better still, present a smooth enamelled surface, which can be washed down with a hose; of course, all corners should be rounded. The floor must be impermeable, and slope towards an open channel on one side of the room, so as to allow of suitable flushing with a hose. All shelves must be made of glass, but the fewer fixtures the better. The heating arrangements should be such that the temperature can be raised, if necessary, to 75° or 80° F. A suitable series of smaller rooms should be available for the surgeon and anæsthetist, for sterilizing purposes, etc. Artificial light must be provided, and electricity should always be employed for the purpose. Gas must be excluded as an illuminant, firstly from the risks of igniting ether vapour, and secondly from the chemical changes induced thereby in chloroform, resulting in the production of poisonous fumes. The lamps should, for choice, be fixed to the extremity of a long arm attached to one of the walls, thereby avoiding the presence of dust-collecting wires and pulleys over the table.

In a private house the room must, if possible, be carefully pre-

pared beforehand. The carpet should be taken up and curtains removed. The walls should be wiped over with an antiseptic solution, and the floor thoroughly scrubbed; all unnecessary furniture is removed. Should the operation be an emergency one, without time for such complete preparation, it is often wiser to leave things alone, and not stir up dust and dirt by a hurried attempt to make the place look a little better than it really is. A suitable supply of hot and cold boiled water must be secured beforehand, and basins and dishes, etc., should, if possible, be previously boiled.

2. The **Surgeon** must remember the very grave responsibility that rests upon him in undertaking many of the modern operations, and he must be willing and ready to submit himself to the strictest régime. In a general hospital he will probably lay aside his outdoor clothes and boots, and don an operating suit consisting of a soft white shirt, white 'drill' trousers, and a pair of clean shoes; he will then proceed to purify his hands and arms, and finally puts on a sterilized gown reaching to the wrists, a sterilized cap and mask covering the whole face except the eyes, and sterilized gloves reaching *over* the lower end of the sleeves. The *assistants* will be similarly prepared. Where such a complete change is impossible, the shirt-sleeves must be turned up well above the elbows, and other preparations made as before. During the operation unnecessary talking is forbidden, and if one has to cough or sneeze the head is turned completely aside.

Similar rules hold good in regard to the *nurses*, who should wear sterilized gowns, and caps to cover the hair. Those actually assisting in the operation will also wear masks and gloves. In all operations involving the upper part of the body the *anæsthetist* must also be suitably garbed, and his hands and apparatus sterilized or protected.

The **hands** and **arms** must be as thoroughly and effectively purified as if no aseptic coverings were available. They are scrubbed thoroughly with soft or ether soap and hot water; the nails are cut if need be, special attention being directed to the semilunar folds of skin at the base, where infected material is apt to collect. For this purpose a purified nail-brush is employed with advantage, and if a running stream of hot water can be obtained, so much the better. It is possible that simple washing with soap and hot water for ten minutes is sufficient to purify the hands and arms, but in our opinion it is wiser to bathe them also in an efficient antiseptic solution—*e.g.*, a 1 in 500 solution of biniodide of mercury in 70 per cent. methylated spirit for one minute, and then in a 1 in 2,000 sublimate solution. The hands and arms, once purified, should not be dried except on a sterilized towel.

The thin **rubber gloves** used in surgical work can be sterilized by dry heat, or boiled in water without soda. Dry sterilization is preferable, but unless care is taken the gloves are liable to be damaged. The interior is well dusted with talc powder, and a piece of gauze introduced to keep the surfaces apart; the ends

should be folded up over a piece of gauze so that the glove can be put on without touching the outer surface; the gloves are finally placed in a cotton bag for sterilization. To put on such gloves, the hands after effective washing and purification are dried on a sterilized towel, and dusted over with sterilized talc. The glove is held by the turned-back cuff and slipped on so that the bare hand never touches the outer surface. If gloves are boiled, they must be filled partly with water and placed in a bag or cage; otherwise they float to the surface and do not get completely sterilized. Boiled gloves are best put on by everting them, and anointing the interior with sterilized glycerine; or the hand may be immersed in methylated spirit, and the glove then slips on easily.

Cotton gloves are used by some surgeons, and several pairs may be required during a single operation; they do not appear to be so satisfactory as the rubber. For operations on bone where punctures are liable to occur, sterilized cotton gloves should always be worn over the thin rubber.

Much of the success of an operative clinique depends upon the methodical and effective organization of the same. It is desirable that all unnecessary hands should be eliminated, and therefore everything likely to be needed should be laid out within reach of the surgeon and his assistants on suitable side-tables, so that they may be able to take up instruments, ligatures, and sutures, etc., without being touched by others.

3. **Instruments** are sterilized by boiling in a weak solution of bicarbonate of soda (1 per cent.) for five or ten minutes, or more if they have been previously used for a dirty case. To prevent them from rusting, they should be carefully plated, and the water ought to boil for some minutes before they are immersed, in order that the suspended air may be driven off. After boiling they may be laid out on a sterilized dry towel and covered over with a similar towel till they are required, or kept in a weak antiseptic solution—*e.g.*, carbolic lotion, 1 in 60. Mercurial solutions should be avoided, as they spoil the instruments. If during an operation an instrument which has not been previously sterilized is required, it may be quickly purified by immersing it for half a minute in liquefied carbolic acid, the excess of which is removed by washing thoroughly in alcohol or hot sterilized water. The same process or re-boiling must be adopted for any instrument which falls on the floor or becomes otherwise soiled. Special care must be directed towards the forceps, to see that the serrations are freed from dried blood-clot and other dirt. Hæmostatic forceps should be opened before boiling.

4. **Swabs** have now so completely taken the place of sponges in surgery that it is unnecessary to consider the preparation of the latter. Swabs are made of absorbent wool wrapped in a single square layer of gauze, the corners of which are tied across and tucked in; or they may be composed of gauze alone, folded over, and perhaps stitched so as to leave no free edge which may fray out; or they may be formed of larger squares of absorbent material, such as gamgee

tissue. A sufficiency of these, suited in size and shape to the requirements of the case, is provided before the operation. They are sterilized in a suitable autoclave or sterilizer, and kept in the drum until required, when they are removed by sterile hands or instruments to a sterile receptacle, being used dry or after immersion in lotion. In case of need, where a sterilizer is not available, they may be boiled and then kept either in boiled water, covered over till required with a sterilized cloth, or in an antiseptic solution; or may be dried in an oven after being enclosed in a suitable cloth.

Cloths and gauze strips for abdominal operations are prepared in a similar manner. In these cases a careful record must be kept of the numbers used, so that all may be accounted for afterwards; indeed, it is wise always to have swabs, etc., done up in packets or bags containing a known number, such as a dozen.

5. The **Ligatures** and **Sutures** demand very thorough purification, which varies with the material used. Silkworm gut, horsehair, and silver wire, which do not imbibe fluids or become absorbed, merely require to be boiled, but silk and catgut need much more care if stitch suppuration is to be avoided. **Silk** must be boiled for twenty or thirty minutes, and should be wound loosely on reels or winders, so that the deeper strands may become sterile as well as the superficial. It may be used at once or after being kept in spirit or in some antiseptic lotion, such as a solution of sublimate (1 in 1,000), for a week or until required, so that its strands may become well impregnated with the salt. An important precaution in the use of silk is to soak it in sterilized water before use, especially if it has been kept in spirit; the object of this is to protect the tissues from the caustic action of the latter, and thereby hinder stitch suppuration. Moreover, silk should *never* be *used with ungloved hands ;* the strands cut through the epidermis and become contaminated by germs lying in the deeper layers of the skin, and stitch suppuration may result.

Catgut is still more difficult to purify, inasmuch as boiling in water is out of the question. Lord Lister claimed that catgut, prepared according to his directions (p. 330), remains actively antiseptic for an indefinite period, and that it suffices before use to immerse it in a 1 in 20 solution of carbolic acid for a quarter of an hour. The majority of surgeons, however, prefer to sterilize it before use, and especially so if they use non-chromicized gut or catgut which has been hardened in a 5 per cent. solution of formalin for twenty-four hours. Many different processes have been recommended, but perhaps the simplest and most effective is that known as the 'iodine' method. The catgut is wound loosely on a glass spool or winder, and immersed in a solution containing iodine, 1 part; iodide of potassium, 1·75 parts; and distilled water, 100 parts. It is kept thus in the dark for twelve days, and then removed and kept dry, wrapped in sterile gauze or placed in sealed sterile bottles. Before use it is placed for a few minutes in spirit (rectified or methylated), so as to dissolve out a little of the excess of iodine present. Catgut so prepared is not only aseptic, but also actively antiseptic, and

rarely causes trouble in the tissues (except, perhaps, in delicate children). An extensive experience of this material for some years has proved its reliability and value. Various instrument-makers provide sterilized catgut in sealed glass tubes, which can usually be trusted.

6. The **preparation of the patient** must be directed not only to the site of operation, but also to the general condition. If the operation be one of any gravity, it is often wise to let the preceding day be spent quietly and restfully, possibly in bed. An effective evacuation of the bowels should be secured, but undue purgation is quite unnecessary; only a light evening meal is permitted. A good night's sleep is essential, and if need be a hypnotic is administered; this is the more important if by any chance the operation is put off, and for want of it mishaps, such as attempted suicide, have before now occurred. An operation is to many a terrifying procedure, and the *morale* of the patient must be studied, and undue fear countered by cheery conversation and company. Nurses by chattering about previous cases and experiences may do an infinity of harm. On the morning of the operation an enema is usually desirable, and some simple fluid nourishment is administered two or three hours previously. Hints as to clothing, etc., so as to diminish shock are given at p. 283.

The *skin* of the patient must be cleansed beforehand in accordance with the instructions of the surgeon. Many methods are available and effective, but the following, which has been tested abundantly, is possibly the best and simplest: The part is shaved, possibly the preceding evening, and washed with ether soap and hot water. It is then thoroughly dried with a sterile towel, and if thought necessary swabbed over with ether or acetone. A solution of iodine in *rectified*, not methylated, spirit, 2 or 2·5 per cent., is then painted over it and allowed to dry, and a sterile dressing applied. This painting with iodine is repeated once again at the time of operation. The all-essential element in the employment of iodine is that the skin to which it is applied should be dry; moisture causes the cells of the prickle-celled layer to swell up and hinders the action. In casualty work it may be advisable to omit the washing with hot water, and merely to cleanse the parts with ether or acetone, and then apply the iodine.

Picric acid (1 per cent. in water or 3 per cent. in spirit) may be employed instead of iodine. It is more penetrating, and therefore more effective and persistent; it is much cheaper, as methylated spirit may be used with it; but it is liable to stain the dressings and bedding, etc., and is therefore disliked by nurses. After the preliminary washing with soap and water a piece of sterilized lint soaked in the aqueous solution is applied, and over this non-absorbent wool (sterilized) is bandaged. At the time of operation the 3 per cent. spirituous solution is painted over the part.

Harrington's solution is used by some surgeons in the final preparation of the skin; the area is swabbed over with it, and after a

few moments it is washed off with methylated spirit. The formula is as follows:

Methylated spirit 94 per cent.	640 c.c.
Acid. hydrochlor. (commercial strong)	60 c.c.
Hydrarg. perchlor.	0·8 grm.
Water	300 c.c.

Special care must, of course, be given to all parts where dirt is liable to accumulate, such as the umbilicus, external ear, toes, or corona glandis in a person with a long prepuce; but undue scrubbing and rubbing are to be deprecated as likely to determine a certain amount of dermatitis, or to wake up into activity germs lying dormant in the deeper part of the skin.

7. The **area of operation** is surrounded by mackintoshes, which should always be purified or sterilized, and these in turn are covered with dry sterilized towels, fixed to the skin by suitable towel-clips. Failing dry sterilization, the towels may be boiled and subsequently dried by baking in an oven, or soaked in an antiseptic solution. As soon as the incision has been made, sterilized cloths made of 'tetra' or other similar material may be clipped over the edges of the skin so as to prevent the surgeon's hands from being in contact with it and thereby causing defilement.

8. The **operation itself** should be carefully thought out in advance and carried through without undue delay. The mere exposure of the subcutaneous tissues to the air does some amount of harm and necessarily increases the risks of infection. The absence of pain granted by anæsthesia is no justification for dawdling, but nothing is gained by undue and showy rapidity. Gentle handling of the tissues and the absence of unnecessary force are essential elements of good operating that must never be overlooked. Clean cutting does less harm than tearing tissues apart, which always means increased reaction. Bleeding should be reduced to a minimum, and known vessels may be picked up with advantage by hæmostatic forceps before division, especially in the axilla and neck.

9. Before closing the wound absolute **hæmostasis** should be secured, and then the wound may usually be stitched up completely and without drainage. It is important to build up again the divided tissues of the part by suitable buried sutures, so as not only to secure more perfect apposition, but also to obliterate 'dead spaces' in which blood-clot or effusion may collect. In this way wounds through fleshy and vascular structures may sometimes be closed completely without drainage On the other hand, where accurate apposition of tissues and obliteration of cavities cannot be obtained, as after clearing out the axilla, and where some amount of oozing may be expected, it is always desirable to insert a drainage-tube, and stitch it flush with the surface. It is removed at the end of forty-eight hours at most; in such cases the removal of the discharge and the changing of the soaked and perhaps stiffened dressings add materially to the comfort of the patient.

When the operation has been completed, the skin around is

cleansed with lotion, but *only after a piece of dressing has been placed as a protection over the wound.* This cleansing should always be accomplished by wiping peripherally away from the wound, and any swab utilized for this purpose should not again be allowed to touch it.

10. Finally, a carefully arranged **Dressing** is applied, and the part bandaged and placed at rest on a splint or in a sling, if such is indicated by the requirements of the case; absolute rest and quiet are essential if rapid healing is to be obtained.

Lord Lister pointed out many years back that the main essentials of a good dressing consisted in its containing some trustworthy antiseptic ingredient; in this agent being so stored up that it cannot be dissipated before the next dressing; in its being entirely unirritating; and in the capacity of the fabric readily to absorb blood or serum that may ooze from the wound. The original antiseptic dressings—viz., the carbolic and eucalyptus gauzes, and even the alembroth gauze and wool—failed to fulfil these requirements; but in the double cyanide of mercury and zinc gauze we have a material which is to all intents and purposes perfect. It should be soaked for some hours in carbolic lotion (1 in 20), and applied to the wound without fear after wringing it out of a 1 in 40 solution; the object of this is to remove any perchloride of mercury which may remain in the gauze as a result of its method of preparation; the irritation sometimes seen around a cyanide gauze dressing is due to this cause; it was never intended to be used as a sterilized dressing. A sufficiency of the gauze is employed, so as to cover in a wide margin of skin all round the wound, and, finally, over all a liberal covering of sterilized or antiseptic wool, so as to diffuse the pressure, which is applied by means of careful bandaging. The best material for bandages is butter-cloth, since it is light and adapts itself easily to the outlines of the part. Other dressings, such as boric lint, iodoform gauze, etc., are occasionally employed, but they are not so satisfactory for general use as the cyanide gauze.

Most surgeons, however, employ simple sterilized gauze without any antiseptic ingredients, and where complete asepsis has been maintained and no great amount of discharge is expected, this will suffice admirably. An antiseptic dressing is, however, an extra safeguard that may be wisely adopted, and especially in cases where a good deal of post-operative oozing is likely to occur.

11. **After-Treatment.**—If no drainage-tube has been employed, and the dressing is not soaked through, it may be left untouched for seven or eight days, at the conclusion of which period it is removed, the stitches are taken out, and in all probability the wound will be completely healed. When a drainage-tube has been inserted, it is usual to take it out at the end of twenty-four or forty-eight hours; there is no advantage in retaining it longer, since it is only required for the removal of the sero-sanguineous fluid which exudes immediately after the operation. Should this early discharge be very abundant and soak through the dressings, there is no actual need to

remove them and re-dress during the first twenty-four hours, if cyanide gauze has been employed; all that should be done is to damp the stained external bandages with 1 in 20 carbolic lotion, and then pack on some more gauze or wool; this may even, if necessary, be repeated a second time. Where merely sterile gauze has been used, it is essential to re-dress the wound completely.

The **after-dressings** of the wound need to be conducted with the same precautions as to asepsis of hands, instruments, etc., as the original operation, and not a few instances of infection at the first dressing occur. It is essential that everything likely to be required should be prepared before the dressings are removed, so that exposure to the air may last as short a time as possible. If the first dressing is undertaken after twenty-four or forty-eight hours, and all is going on satisfactorily, the tube is removed, and the wound re-dressed in exactly the same way as formerly, though probably much less gauze will be required. If the case is left for eight days, the stitches can probably be taken out, and the skin incision will then be found united. A small dressing of sterilized or cyanide gauze is applied, fitting closely to the scar, and sealed down with flexile collodion, which will not only prevent the gauze from slipping, but will also by its contraction serve to steady the parts. This should be covered with wool and a bandage, so as to support the parts, and may be finally removed at the end of another week.

An **open method** of treating certain operation wounds may sometimes be adopted with considerable advantage. Absolute hæmostasis is the first essential, and the wound must be completely closed without drainage. It is carefully dried and painted over with 2 per cent. solution of iodine in spirit. A sterilized towel may be placed around the part for the first twenty-four hours; but this may be discarded afterwards, and the wound is left uncovered, and merely painted daily with the iodine solution. In the case of children some arrangement of the bed-clothes must be devised to keep their fingers away from the part. Hernia operations and similar wounds do excellently under this régime, especially in warm weather.

CHAPTER XI.

THE USE OF PHYSICAL AGENCIES IN SURGERY.

WITHIN recent years there has been so large a development in the application of various physical agencies in the realm of medicine and surgery that it is desirable to discuss their powers and application in one chapter, and we propose in this to treat of the use of massage, remedial exercises, heat, light, electricity and radio-activity, etc.

Position.—It must be remembered that the surgeon's work is not completed when the immediate lesion for which he is responsible is repaired; his duties also extend to the subsequent period of restoring functional activity to the parts involved. Thus it is not enough merely to secure the union of a broken bone; it is the duty of the medical attendant to take such precautions as shall prevent, if possible, the limitation of movement in neighbouring joints, or to institute treatment for the removal of such stiffness, if it has unfortunately occurred. The excision of a cancerous breast is a beneficent operation, but the surgeon is doing no kind turn to his patient if he allows her to recover with an arm which is so fixed to the side that it can only be raised with pain and difficulty; a little forethought can prevent many a painful disability.

The prolonged fixation of a limb causes many changes which the surgeon must carefully study if harmful effects are not to be produced. In the first place the blood supply suffers, and this may result in defective nutrition, and diminished resistance to bacterial infection. Muscles become stiff from want of use, and if the limb is the seat of hæmorrhagic extravasation due to traumatism or of septic inflammation, extensive fibroid infiltration may follow which it is difficult subsequently to remove. Volkmann's ischæmic contracture (p. 461) is probably of this nature. Joints are not seriously involved by prolonged immobility unless intra-articular pressure due to weight-carrying or to muscular spasm is superadded, and then fibrosis of ligaments and thickening of the synovial membrane with the production of adhesions may result in limitation of movement, fixity in a bad position, or other troubles. Still more likely is this to occur if peri-articular inflammatory troubles of bacterial origin are in existence. or if the patient is suffering from any marked

degree of toxæmia. Definite atrophy of bone also occurs when prolonged rest is maintained.

It is essential, therefore, that if a limb is to be fixed in one position for any length of time, that position shall be selected which will lead to as little subsequent disability as possible and shall permit rapid restoration of function when once the necessity for fixation has come to an end. It must be remembered as a cardinal principle that *it is always easier to relax a stretched muscle or tissue than to stretch one that is contracted;* and hence if particular structures are liable to contraction which will be difficult to overcome, these structures should be put on the stretch during the period of immobilization. A few specific illustrations will be useful. (*a*) Prolonged fixation of the arm to the side is always liable to be followed by contraction of the pectoralis major and latissimus dorsi muscles,

FIG. 89.—HAND IN WRONG POSITION FOR PROLONGED FIXATION.

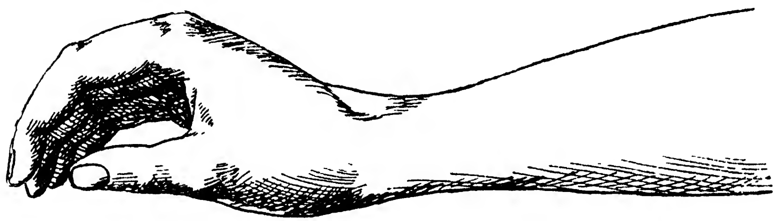


FIG. 90.—HAND IN CORRECT POSITION FOR PROLONGED FIXATION.

and much pain and discomfort have to be experienced before the arm is once again freely moveable. This is likely to be aggravated in cases of axillary cellulitis or suppuration where cicatricial tissue has to develop between or in the substance of these muscles. In these cases the arm should always be kept at right angles to the trunk as has now been the custom for some years in the post-opertive treatment of scirrhus mammæ; it is then easy when the time comes to drop the arm to the side. If, however, there is a likelihood of osseous ankylosis occurring at the shoulder joint, the arm must not be kept away from the side for more than about half a right angle. (*b*) Grave limitation of movements of the wrist and fingers is always liable to follow prolonged immobility of the hand. If it is kept on a splint in the position indicated in Fig. 89, it is obvious that the interossei are contracted, and it will be difficult to stretch them subsequently, whilst the flexor tendons are on the stretch, and thus

liable to become adherent to their sheaths. Whenever possible, the fingers and thumb should be left unbandaged so as to be free to move, and the wrist must be kept at rest in a slightly hyper-extended position on a 'cock-up' splint (Fig. 91). If the fingers and thumb must be immobilized, the position to be adopted must, if possible, be that indicated in Fig. 90—*i.e.*, as if the patient were attempting to pick up a large ball. (*c*) In conditions involving prolonged fixity of the forearm—*e.g.*, septic compound fractures of radius and ulna, the hand should be kept in a position of full supination; otherwise the supinators become stretched, fibrous and atrophied, the pronators are contracted, and subsequent supination (always the weakest movement of the forearm) becomes almost an impossibility. If, however, it is probable that subsequent rotation of the forearm will be entirely lost, the hand should be kept almost midway between pronation and supination, but with the palm turned a little upwards. (*d*) Whenever it is likely that the necessary development of scar

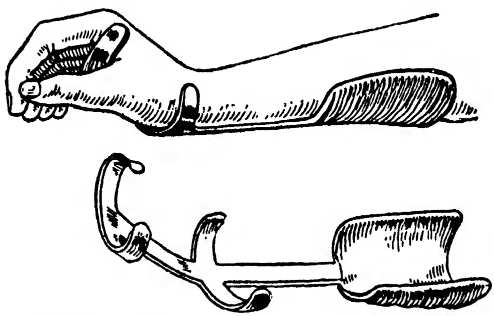


FIG. 91.—'COCK-UP' SPLINT FOR HYPER-EXTENSION OF WRIST. (Sir R. Jones.)

tissue will lead by its inherent contractility to subsequent deformity the limb should, if possible, be placed in a natural or even hyper-corrected position so as to allow for contraction; thus, in a septic transverse wound of the gastrocnemius fibroid changes occur which result in drawing up of the heel into an equinus position necessitating division of the tendo Achillis at a later date, this should be prevented by placing the limb on a splint which maintains the foot at right angles.

Prevention of a deformity by the surgeon's forethought is always better than its cure by the most ingenious skill.

Massage.—Massage, or the skilled rubbing of a part, is of the greatest value in many conditions, and has been employed to a great and increasing extent for some years past. All doctors and nurses should know something of massage from a personal and practical standpoint, but it is usually entrusted to specially educated and trained agents for its due performance, and one must refer readers to special textbooks if they desire to study fully its value and method of application.

The chief varieties of movement are known as effleurage, pétrissage, and tapotement. *Effleurage* consists in plain up and down rubbing of the limb with the flat of the hand, the up stroke being always firmer than the down, so as to assist in the return of the blood and lymph from the part. In this way the circulation is quickened, and the vital activities of the tissues are increased. The skin should be lubricated with oil, vaseline, or some stimulating embrocation, or dusted with oxide of zinc or French chalk, and the rubbing, at first light, so as only to affect the skin and subcutaneous tissues, should gradually become firmer, so as to influence the deep structures. *Pétrissage* consists in kneading the muscles or other tissues between the finger-tips and the palm of the hand; this necessarily should be done across the muscle fibres, working from below upwards, and is especially valuable in hastening the absorption of exudations. In *Tapotement* a series of blows perpendicular to the surface is rapidly delivered by the ulnar side of the open or clenched hand; the circulation in the parts thus struck is much quickened, and when skilfully done no pain should be caused.

As a modification of the last proceeding, *Vibro-massage* has been recently introduced, in which rapidly repeated blows of the affected region give rise to a vibratory effect, which is often of the greatest value. Hand vibrators are sold, and may be used with advantage; but the best results follow from the employment of vibrators worked by electricity. Rheumatic inflammation of joints and fasciæ, such as occurs in lumbago, some forms of sciatica, and other neuralgic conditions, are often much benefited by this procedure.

It is only possible to allude here to a few of the many conditions for which massage is beneficially used.

1. When applied lightly, and only dealing with the superficial parts, it is soothing in its effects and may be employed for the relief of pain; all hyper-sensitive areas should be treated in this way to commence with, not only to ensure comfort, but also to gain the patient's confidence. The lightest finger-tip massage (stroking) is most soothing, and its application to a patient's head and face late at night will sometimes assist in overcoming sleeplessness (as the writer can gratefully testify). It may also be employed to allay muscular spasm soon after a fracture.

2. Deeper massage of all types is valuable in assisting in the absorption of inflammatory exudates and in increasing the amount of healthy blood in a part. The driving out of the stagnant lymph and blood from the tissues prepares the way for a better supply of healthy blood, and thereby repair can be expedited. It is obvious, however, that massage must be sparingly employed where infective material is present, and might be dislodged or driven into the general circulation by injudicious manipulation. It is therefore more frequently employed in chronic affections, and only in the later stages of acute troubles.

3. It is largely used and extremely beneficial for its purely mechanical effects in freeing adherent tissues and restoring to them their

power of independent utility. As a result of hæmorrhagic or inflammatory effusion, muscles get matted together, or fixed to bones, or perhaps all the tissues of a limb seem to be hopelessly welded into a solid mass, especially if it has been necessary to maintain prolonged rest after a septic injury, as in many gunshot wounds. In such cases, as soon as possible consistent with safety, massage should be commenced so as to free the parts from their intimate union with each other, and make them once again independent entities. Adhesions in tendon sheaths and joints may be largely influenced for good by suitable massage, but active movements under an anæsthetic to break these through are sometimes required.

4. Massage is of great value in many cases simply by increasing the blood supply to the part, and thereby encouraging repair. Many a fracture which is slow in its progress and in which union is delayed may be hurried up by suitable massage, and sluggish wounds of all sorts may be stimulated thereby.

5. Deep organs may be affected equally with the superficial, and in many abdominal conditions massage may be beneficially employed. Thus in chronic constipation massage along the course of the colon, is often of more use than medicine, especially if combined with suitable exercises for employing the muscles of the abdominal wall.

6. General massage of the limbs and trunk is often ordered so as to maintain the general health of the body during a period of enforced rest. It thereby provides exercise without effort, and function without fatigue. Perhaps it is of most value in cases of nerve prostration when sleep and over-feeding are required to build up the tone of the nervous as well as of the physical system. Similarly local massage is employed to maintain the vitality and flexibility of parts that must be kept at rest for a long time—*e.g.*, limbs with fractured bones or divided nerves.

Remedial Exercises.—There are limits, however, to the usefulness of massage as a remedial agent, for the effective restoration of the functions of muscles and joints can only be brought about by movement. There is but little doubt that in the past the medical profession has been unduly conservative and cautious in this direction, thereby playing into the hands of unqualified practitioners of the bone-setter type. Remedial exercises are both passive and active in character, and some little discrimination must be employed in the selection of suitable exercises in particular cases.

Passive Movements do not involve any great strain upon a part, and are to be employed at as early a date as possible. They are usually undertaken by a trained rubber, but any intelligent nurse can do what is required. All parts which do not require to be immobilized should be exercised in this way daily. Thus in a closed fracture of the forearm it is quite possible to move each joint of the fingers daily, and even with care the elbow and wrist; pronation and supination must be delayed until the bones are united, but in two or three weeks it is possible that this movement may be com-

menced. In a case of fractured clavicle passive movements of the elbow may be permitted from the first, and active movements of the fingers and wrist; but the shoulder and clavicular joints are kept at rest for about a fortnight, and then cautious movements are permitted. In inflammatory troubles of the hand and foot one cannot emphasize too strongly the necessity for early passive movements of all parts other than the chief focus of trouble.

When once stiffness of a joint has supervened, whether due to intra- or extra-articular causes (other than osseous ankylosis), it is often a matter of grave difficulty to restore mobility. It may be necessary for the surgeon forcibly to break down adhesions under an anæsthetic as a preliminary to further treatment, and then after a short interval to institute suitable exercises.

Active Exercises must replace passive movement as soon as possible so as to introduce the important element of will-power. In muscle re-education the limitations of the weakened structures must be respected, however, and an impossible strain must not be placed upon them. Thus in abducting the arm from the side the deltoid has not only to influence the humerus, but also to lift the weight of the arm—often too great a task for a weakened muscle. If the patient is placed lying on a couch so as to support the weight of the arm, the deltoid can often effect the angular displacement of the limb into a position of abduction when it would be impossible to lift it in the standing posture. A similar suggestion applies to the knee; the quadriceps may be able to extend the leg if the weight be removed by lying on the outer side, whereas it is impossible at first to take the 'maximum load' by lifting the unsupported leg and foot. All re-educational exercises must take such facts into consideration.

Weakened muscles may at the same time be helped and toned up by massage, electrical stimulation (sinusoidal current), etc., but these are to be looked on merely as accessories.

Machines have been much vaunted as valuable helps in regaining movements of joints, and rightly employed they may be useful. Some machines provide passive movement alone, and merely replace a masseur by mechanism. Others introduce the principle of the fly-wheel, the continuous revolution of which will maintain and increase the movements of the limb which is attached to it. Still in others the patient uses sound muscles to lift a weight by a rope passing over a pulley, and on letting it fall a contracted muscle may be stretched.

Active Exercises against Resistance are also much employed in order to tone up muscles which have lost power, and ligamentous or tendinous structures which have been damaged. The efforts are made either against the trained muscles of a masseur, or against the increasing friction of a machine. As the structure becomes stronger, the resistance is increased, so that finally the part may be safely exposed to the unlimited strains of normal life. This method of treatment is particularly valuable in dealing with the knee-joint after an operation involving ligaments; the strain of weight-carrying,

especially if the patient is tall, is very severe, and until a full course of exercises against resistance has been given, the patient should not be allowed to walk.

There is an undoubted place for all these varieties of exercise, but they have their limitations, especially when a nervous defect is superadded to the muscular or articular lesion. The patient's will must be brought into action, as well as his muscles rubbed or his limbs moved by machinery, and in this direction **Active Exercises in the Gymnasium** under suitable supervision are of more value than many machines. It is impossible here to elaborate gymnastic methods, but a few general principles may be referred to.

1. It is useless to expect a patient to exercise one damaged muscle by itself. The associated action of a group of muscles, of which the damaged one is a member, should always be attempted, and the patient often uses the damaged part unconsciously when his interest is mainly concentrated on other things. Thus in re-educating the supinators, which frequently become very weak, it is better to teach the patient how to swing an Indian club than to set him to the monotonous task of rotating handles against resistance. The pendulum-like swing of the club is helpful, and the improvement of the general tone and vascularity of the whole arm is a most valuable asset.

2. Equally important is it to remember that bilateral movements are often more easily acquired than when only one limb is used, and effects are hereby often produced in a short time that previously seemed impracticable.

3. Not unfrequently it is possible to secure movements of joints by suitable games, in which the patient does not realize all that he is doing. For stiff arms and legs there is nothing much better than a game of skittles; if the patient is made to bowl the ball properly, most of the joints in the body are exercised.

4. One must insist, in conclusion, on the immense influence mind has over matter. The fact that some response is obtained to the efforts put forth is a great incentive to further effort; when a man's fingers have been kept stiff and rigid for a long time, it is a great thing when he realizes for the first time that he can impress and indent something with them. A useful plaything for this type of patient is the handbag or abacot,* a leather-covered air cushion shaped like an Indian club. Constant handling of this contrivance gives the man's sensorium a feeling of satisfaction and confidence as his grip improves.

Heat (Thermo-Therapy).

Apart from its value as a sterilizing agent, heat is of use in treatment on account of the active arterial hyperæmia it produces, whereby the part to which it is applied is bathed with fresh blood containing defensive agents, such as leucocytes, opsonins, antitoxins,

* The 'Abacot' is made by Messrs. Spencer, Heath and George, 48, Goswell Road, E.C.

and other antibodies, by means of which the activities of harmful bacteria and their toxins are neutralized. Moreover, when applied to a part which is infiltrated and brawny, it assists in the restoration of a healthy circulation by softening and relaxing the tissues.

Heat is employed in two chief forms—viz., as moist or dry heat—and either may be utilized as a general or a local application.

1. **Moist Heat** is utilized *locally* in the form of the fomentation or poultice (p. 39), in order to assist an inflamed part to healthy repair. It matters little as to the material employed when the skin is unbroken, so long as it retains the heat, and, with this object in view, a linseed poultice is often preferable to a fomentation. When, however, there is an open wound, the fomentation or poultice must be aseptic at least, if not antiseptic, in character. The *boric fomentation* is useful in these cases, consisting of boric acid lint wrung out of boiling water, or a *carbolized poultice* may be employed. This latter consists of linseed-meal mixed with boiling lotion (1 in 60), and applied to the wound over a few layers of cyanide gauze.

Generally, moist heat is employed in the form of a *hot bath*, and, apart from its cleansing purposes, this is most valuable in many conditions and for varying purposes—*e.g.*, to act as a sedative in cases of slight shock and general bruising of the body after accidents; to assist in the painless removal of extensive dressings which might stick to raw surfaces, such as burns, especially in children; to dilute toxins and help in their removal from the body, as in extensive infected wounds. In cases of wounds, isotonic salt solution, and not plain water, should be used (p. 93).

The *hot bath* is also used in various schemes of hydro-therapy in order to act upon many foci of chronic inflammatory trouble—*e.g.*, in general muscular rheumatism and fibrositis, the heat of the bath helps to relax and loosen the parts, and thereby to restore them to a healthy function. Plain water may be utilized for this purpose, or hot mud or peat baths. Massage of a portion of the body over which a stream of hot water, either in one large jet or from innumerable small ones, is passing constitutes the basis of the so-called *Aix or Vichy douche baths*, which are both pleasant and profitable methods of treatment for chronic inflammatory lesions of the fibrositis type Active chemical substances, such as alkaline carbonates, sulphur, etc., naturally present in the water, or artificially added to it, are readily absorbed through the skin, and influence the patient considerably; natural mineral waters are probably more active than those artificially prepared. Alternating hot and cold baths are also of value in stimulating reparative changes.

2. **Dry Heat** may also be made to serve as a therapeutic agent, generally or locally, but in most instances introduces a new element—viz., diaphoresis as well as superficial hyperæmia. It is especially valuable in chronic cases, and, of course, higher temperatures can be borne without discomfort than in the preceding variety.

Generally, various methods of hot air or vapour baths are avail-

able. *Turkish baths* consist in the exposure of the unclothed body to dry heat at varying temperatures (up to 250° F. or more) for twenty or thirty minutes; by this means an abundant perspiration is induced, and thereby toxins are eliminated. It is followed by massage, douching, and rest for an hour or so, during which an abundance of plain cold water should be drunk. A *Russian bath* is very similar, but the air is full of the vapour of steam, and therefore cannot range so high; perspiration is induced more rapidly, and the bath is of shorter duration. In both of these agents the object is to induce the rapid elimination of toxins and other poisons, and at the same time to assist in maintaining the free mobility and function of the various parts of the body by massage.

In patients who are incapable of leaving their beds or homes—*e.g.*, in cases of uræmia, or of very bad chronic rheumatism—hot-air baths may be given by covering the patient with a large cradle over which is placed a blanket or two, and under it, in such a way as not to endanger him, a lighted spirit-lamp or a suitable number of electric lights of sufficient power. Occasionally, however, wet packs have to be relied on in such cases.

Locally, there are many methods of applying dry heat to a part, of which the following are the chief:

(1) *Hot-air baths*, such as the Sheffield-Tallerman apparatus, etc., consist essentially of a box or chamber with walls composed of felt or asbestos, and arranged so that the contained air can be heated to a required temperature by an oil or gas burner. The affected limb is introduced into the chamber through a window with a closely-fitting curtain, and carefully suspended to prevent the skin touching the hot walls.

(2) *Radiant-heat baths* have electric incandescent lamps as their heating agents. The therapeutic value of these baths depends not only on the hot air evolved, but also, and probably mainly, on certain light rays which have no heating power. A bath consists of a cabinet containing a number of lamps, which may have various-coloured globes, so that, by absorbing rays corresponding to certain portions of the spectrum, the quality of the light may be varied. They may be used for the whole body or for individual limbs.

(3) In *Diathermy*, or thermo-penetration, a high-frequency current of extremely rapid oscillation (about a million a second) is employed; the oscillations being so rapid and more sustained, the current can be passed through the body without pain, unless from over-heating of the tissues. The potential being high, the body offers resistance to its passage, and thus the temperature is raised along the track of the current, as when any other current passes through a resistance. The action of this agent therefore differs from that of hot-air baths, etc., in that the *internal* temperature of the part is raised rather than the external air, and hence the therapeutic results are increased. It is easy to localize the effects by the use of suitable terminals.

Applications.—Hot-air and radiant-heat baths are chiefly employed to promote the absorption of chronic inflammatory exudates, and for such conditions as chronic arthritis, adhesions, neuralgia, lumbago, and sciatica. They are also used to aid elimination by determining diaphoresis in general toxic conditions, such as gout, Bright's disease, and obesity. Diathermy is useful for chronic inflammation, osteo-arthritis, rheumatic and gouty fibrositis, as also in gonococcal lesions.

Heat is of great value in preventing or counteracting shock. The importance of keeping a patient warm during a lengthy operation has been emphasized more than once, and to this end operating rooms are now maintained at a high temperature (70° to 80° F.) and the patient is carefully clothed. To combat the shock which follows operations or serious injuries, such as bad burns, especially in children, when the patient's temperature often falls as low as 95° or 96° F., it is important to surround the body with air at a higher temperature; and this can be effected by covering him with a cradle over which a blanket is placed, merely leaving the head uncovered, and within which is placed an electric lamp of 50 or 100 candle-power, so that it cannot touch or be touched by the patient's limbs. The result of this hot-air bath is often most valuable.

Cauteries are employed in the application of heat to the tissues of such an intensity as to burn them. Their uses in this direction are twofold:

1. As a *counter-irritant*, with a view not only to affect indirectly the underlying process of disease, but often rather to assist in the diminution of pain. Thus a painful joint or spine can be beneficially influenced by searing lightly the overlying skin. Some resistant forms of neuritis can be improved by this means.

2. More often cauterization is employed as a *hæmostatic* agent. Small bleeding points in situations difficult to reach or to control may be effectively dealt with in this way—*e.g.*, in the nose, or where small vessels in dense scar tissue are difficult to secure. Vascular tissues can be divided by this means without loss of blood, and at the same time the tissues involved are made or preserved aseptic. It is well to remember that a dull red heat is the most effective, since thereby the vessels are seared and closed; a cautery at a white heat cuts almost as cleanly as a knife. The possibility of secondary hæmorrhage when the slough separates must not, however, be forgotten.

The following are the chief forms of cautery ordinarily employed:

1. *Actual cauteries*, which consist of solid irons of various shapes, which are heated in a suitable flame to a temperature depending on the use for which they are required.

2. *The galvano-cautery* consists in a loop of platinum wire mounted on an insulated handle, and connected with the terminals of a battery of sufficient strength. The handle is fitted with a key, so that the current may be opened or closed at will. During

the passage of a sufficiently strong current (5 to 6 amperes for small loops) the platinum becomes red or white hot. This form is of most use for dealing with small bleeding points or for the removal of pedunculated growths, such as polypi.

3. *Paquelin's thermo-cautery* depends on the principle that, when the vapour of benzoline is driven over heated platinum, its combustion generates sufficient heat to maintain or increase the temperature of the platinum. By means of a rubber bellows, air is driven over the surface of benzoline contained in a bottle, and then, saturated with its vapour, through a hollow handle into a platinum point. The platinum point is previously heated to a dull redness in a spirit flame, and on pumping the mixture through the apparatus it can be kept at a red or white heat.

4. The *Diathermic Cautery* is based on the use of the diathermic current, as described above. If one terminal is large and indifferent it may be applied to arm, leg, or trunk without producing localized effects; if the other terminal is small, the current will be concentrated, and along its line of application the tissues will be heated to such degree as to coagulate and destroy them. The active electrode may be varied in shape to suit the requirements of the case, and thus with a strong current and a small cutting terminal tissues can be excised and cauterized at the same moment, and thus hæmorrhage prevented. Malignant growths of the mouth, including tongue, tonsil, or pharynx, excision of which would be followed by severe bleeding, can often be safely dealt with by this agent, as also papillomata, etc., of the bladder. Wounds produced by this form of cautery heal quickly and without pain.

Light.

Light as a curative agent, apart from its thermal effects, is chiefly employed in the form of (1) the arc light, (2) Finsen and mercury vapour lamps, and (3) sun-baths.

1. The light from an *arc lamp*, projected by means of suitable mirrors, can be employed as a general bath or locally to diseased tissues. Whilst it contains a sufficiency of heat rays to necessitate caution when focussing it upon a part, its activity mainly depends on the presence of an abundance of *ultra-violet rays* similar to those in normal sunlight, and thus it is sometimes termed *artificial sunlight*. It may be employed for all conditions, local or general, for which direct heliotherapy is advised—*e.g.*, tuberculous disease, lupus, rickets, and many types of malnutrition. Pigmentation of the skin is produced in exactly the same way as from exposure to sunlight, and the pre autions needed in heliotherapy must be adopted.

2. The Finsen and mercury vapour lamps are methods of exposing small areas of disease to large doses of light containing an abundance of chemically active rays. A *Finsen* lamp consists of a powerful arc. the rays of which are collected and focussed by

quartz lenses on a small area of skin, which is cooled and rendered anæmic by a quartz compressor, through which a stream of cold water flows. Compression aids the penetration of the rays by rendering the part bloodless, the blood having the power of absorbing the violet rays. The *mercury vapour* lamp consists of a glass tube exhausted of air, and containing mercury and mercury vapour. The passage of a suitable current through this produces a light rich in ultra-violet rays. These lamps are chiefly used in the treatment of lupus.

3. *Heliotherapy*, or exposure to the sun's rays, has already been referred to as having beneficial results in the treatment of tuberculous lesions, whether applied locally or to the whole body, and its effects and the precautions which need to be taken therewith have been indicated. It must not be overlooked that an element of aero-therapy usually enters into the cure produced by this means; sunshine and fresh air join hand in hand to promote the physical welfare of mankind.

Apart from tuberculosis, sunlight is of great value in cases of anæmia, rickets, and malnutrition, and also has a distinctly beneficial influence on the treatment of open wounds, which are stimulated to increased activity. All that is needed is to protect the surface with a layer of sterilized gauze. Sometimes the sunlight is so active as to cause considerable irritation, and it is unusual for a wound to be able to stand more than twenty to thirty minutes a day of this treatment.

The fact that normal sunlight is a complex of varied coloured rays has not been forgotten, and the influence of the different elements of the spectrum has been exploited. It is probable that exposure of the body to different coloured lights has a definite effect, especially to individuals of a receptive temperament. Green light appears to be soothing, red to be stimulating and even irritative, and blue depressing. Neurasthenic patients with irritable hearts and constitution may be soothed, stimulated, or depressed by exposure to varied lights, and a definite therapeutic result may be expected.

Electricity.

Electricity, apart from its thermogenic power, has many important applications in the domains both of diagnosis and treatment.

1. **As a Diagnostic Agent.**

(1) By means of the *faradic and galvanic currents* the electrical response of muscles and nerves can be investigated, and valuable information obtained as to the condition of the nervous and muscular systems.

A muscle with a normal nerve-supply contracts under stimulation from both the faradic and galvanic currents in sufficient strength, the contraction being most readily obtained when the electrode is applied over a definite skin area, varying for every

muscle, and called the 'motor point.' With the galvanic current the contraction obtained, when the current is closed, is greater than that produced when the current is opened. Again, the contraction elicited when the electrode applied to the muscle is attached to the kathode of the battery is greater than that resulting when the anodal electrode is used. This fact is expressed in the formula —K.C.C.>A.C.C.

In the muscular degeneration which follows nerve injuries, neuritis, anterior polio-myelitis, etc., these reactions are modified, and constitute the *reaction of degeneration* (R.D.). The response of the muscle and nerve to the faradic current quickly disappears, and with the galvanic current the anodal closure contraction becomes greater than the kathodal (A.C.C.>K.C.C.). A greater strength of current will be required than in the sound side of the body, and the response will be sluggish, and not brisk. As long as the R.D. persists, however, the possibility of repair in the muscle remains, should the centres and conducting apparatus be restored. This persistence of the R.D. may exist for years. When once the R.D. is lost, all hope of repair is gone. In spastic conditions the electrical irritability of muscles and nerves is often increased.

It is most desirable that muscles and nerves should be treated on a standardized scale, inasmuch as the results naturally vary somewhat with the strength of the electrical stimulus. To this end *condensers* have been introduced, whereby it is easy to regulate the strength of the current, and to state in simple and obvious terms the result of the test.

(2) *Radiography.*—When a current from the secondary circuit of an induction coil is passed between two suitable metal electrodes in a vacuum tube of a high degree of exhaustion (Crookes tube), a stream of rays, called 'kathodal' or 'β rays,' which consist of negatively charged electrons, is generated from the kathode. If the kathode is concave, and the rays are thereby made to converge to a focus on a third electrode called the 'target,' or 'antikathode,' from their impact thereon results a production of rays of a very special character, known as the 'X rays of Röntgen.' X rays have the power of penetrating most opaque bodies in varying degrees, and in general terms substances are opaque to X rays in proportion to the atomic weights of their constituent elements. X rays also have the power of acting upon sensitive silver salts in the same way as light, so that if a structure, such as a limb, be interposed between the source of the rays and a sensitive photographic plate, the rays will readily penetrate the softer parts; but their passage will be hindered by the more resistant structures, such as bones, which will thereby throw a shadow on the plate. Radiographs or skiagraphs are the shadow-pictures produced in this manner. The greater the vacuum in the tube, the greater will be the strength of current needed to traverse it, and the greater the penetrating power of the X rays produced. These are known as 'hard tubes.' Soft tubes are those in which

less strength of current is required to produce the rays, which have a less penetrating effect, and therefore are more useful in permitting a greater differentiation of shadow.

Barium platino-cyanide and certain uranium salts are rendered fluorescent by the passage of X rays, so that, if a screen covered with one of these substances is held distal to the limb or part to be examined, a shadow similar to a radiograph is produced and can be seen. The *radiographic screen* is of great value in many conditions as a means of rapid diagnosis, and sometimes gives better results than the radiograph, especially when absolute immobility cannot be obtained. Thus the movements of the heart, of the diaphragm, the pulsations of an aortic aneurism, etc., can be better examined by the screen than by taking a radiograph. As an illustration of this may be mentioned a case where a silver probe had slipped down through a tracheotomy wound into a bronchus. An attempt to photograph it failed completely, but on examination with the screen the probe was seen lying transversely in the left bronchus, moving up and down at each beat of the heart.

Great care is necessary in the interpretation of radiographic pictures, as, the rays being divergent, some distortion of the resulting shadows occurs, according to the distance of the object from the source, and the exact angle at which the rays impinge upon it. To avoid this deception, stereoscopic photographs, or views in two directions at right angles to one another, are necessary. Moreover, the results vary much according to whether the radiograph is taken from before or behind. Thus, if a shoulder is radiographed from behind, the details of the coracoid process and of the head of the humerus will be most clearly defined; whereas if the plate is posterior, and the picture is taken from the front, the acromion and spine of the scapula are more sharply represented. In practice the outlines of bones are clearly seen; cartilage and callus are often transparent; muscles and tendons are sometimes visible if a very soft tube is employed. Calculi vary according to their composition, oxalates being most opaque, and uric acid stones most transparent. Gallstones are seldom impervious (12 per cent. visible). By the use of soft tubes the outlines of viscera, such as the liver and kidneys, may often be obtained.

In the case of foreign bodies it is not sufficient merely to know that they are present in a particular locality. Every operating surgeon knows the difficulty of finding them, and the most serious damage has often been inflicted in the soft parts by attempting their removal on insufficient data. The *exact localization* of foreign bodies is now easily determined by many methods which it is impossible to describe here, but every expert radiographer can give the surgeon invaluable assistance in this direction, and no operation for the removal of a foreign body embedded deeply in muscular tissues, and hence impalpable, should be undertaken without this exact information being previously obtained. Even more help is available from the use of the radiographic screen during the operation, by the

use of which it is possible to see the foreign body during the manipulation necessary for its removal.

It often suffices to take radiographs in two directions—*e.g.*, antero-posterior and lateral—and by a careful comparison of these sufficiently satisfactory data are obtained to enable the surgeon to find the foreign body.

For the employment of X rays in fractures, see p. 534.

2. As a **Therapeutic Agent** electricity is employed in many ways:

(1) The *galvanic and faradic currents* are employed, both generally and locally, for their stimulating action. Under the former heading one would include the use of the *electric bath*, in which a patient lies in water to which a small addition of salt is made, and through which a galvanic current is passed. The effect of this is to increase the superficial circulation and produce cutaneous hyperæmia. It is often useful in diffuse rheumatic and gouty fibrositis, as also in conditions in which the general muscular and nervous tone of the body has been lowered. It is of considerable value in the treatment of conditions depending on arterial spasm, such as Raynaud's disease, as also to prevent chilblains in paralyzed limbs. Care must be taken only to increase or decrease the strength of the current gradually, otherwise the patient may experience an unpleasant shock.

Locally the galvanic and faradic currents find their chief employment in cases of muscular paralysis or wasting, both to prevent degeneration or atrophy, when nervous control has been lost, as by division of the motor nerve, and to build up healthy muscular substance after nerve-suture or when atrophy has occurred from disuse. The *sinusoidal* current is perhaps the most useful to employ in the earlier stages; in this the current is continuous, but is made to vary in strength in a smooth and wave-like fashion without sudden interruptions. Later, the *interrupted galvanic* current is more useful, and is often the only one to which response can be obtained, whether before operation or in the earlier stages of repair. The current must be made and broken at regular intervals, a metronome introduced into the circuit being a useful contrivance. Failing this, the patient may be instructed to remove and replace one of the terminals at regular intervals, thereby stimulating his interest in his own case. When once response is obtained to the faradic current after an operation for nerve-suture, this type of electricity should be substituted for the galvanic current as being more effective.

(2) *Electrolysis* is used chiefly for the destruction of superfluous hairs, moles, etc., and the treatment of nævi, where excision is undesirable. The passage of a current of sufficient strength between metallic poles actually inserted into the tissues sets up an electrolytic action, and coagulation of the blood or local destruction of hair follicles, etc., results.

(3) *Static electricity* generated by a machine such as Wimshurst's or the *high-frequency current* is used in the treatment of neurasthenia, general or nervous debility, or neuralgia, but is

of value rather as a general tonic than as having any specific effect.

(4) *Ionic medication*, or cataphoresis, consists in the introduction of drugs directly into the tissues of the body by means of an electric current. It is based on the principle that the passage of a current through a solution of a salt is accompanied by movement of the constituent ions. The positively charged ions (kations), which include those of all metals, alkalies, and alkaloids, are attracted to the negative pole, while the negatively charged ions (anions), such as those of chlorine, iodine, the acids, and hydroxyl, are attracted to the positive pole. If the human body is interposed in the current, instead of a solution of salt in a vessel, and lint pads, soaked in a solution of the salt or drug, are placed between the skin and the electrodes, kations at the positive pole and anions at the negative pole will enter the tissues and be disseminated in them for a variable distance, probably from 1 to 10 millimetres. The pads should be thick and of large area, and the strength of current 2 to 3 milliampères per square centimetre of area of the pads.

Ionization is largely used in the treatment of chronic inflammation of joints and other tissues and in the softening of scars, but good results have also been obtained in sinuses, chronic ulcers, rodent ulcers, lupus, warts, etc.

(5) The *diathermic current* has already been mentioned as employed as a means of heating the tissues (thermo-penetration, p. 306) or as a cauterizing agent (p. 308).

Radio-Therapy and Radium.

Soon after the discovery of X rays by Röntgen in 1895 it was found that they were capable of setting up severe dermatitis, often accompanied by ulceration, and also had a considerable depilatory power. The question therefore arose whether they could not be employed therapeutically in certain skin diseases requiring either a stimulative or depilatory action, and in no long time sundry cases of lupus were found to benefit by treatment. A large amount of experimental work quickly followed to determine the action on various tissues and organs.

It is now well known that repeated exposures may lead not only to dermatitis and X-ray burns, but also under certain conditions to the development of actual neoplasms; blood changes of a serious type also follow. The genital cells are found to be remarkably susceptible to the action of the rays, the germinal cells of both testis and ovary being easily and permanently damaged, with the subsequent production of sterility. Upon the lining cells of the intestinal mucosa X rays also have a powerful destructive effect, with the production of severe enteritis. From these facts it is evident that radio-therapy must invariably be

carried out with due regard to the safety of both patient and operator.

It may be mentioned here that X rays have now been proved to be electro-magnetic vibrations, similar in character to the Hertzian waves, heat waves, the rays of visible light, and the ultra-violet rays, though of shorter wave length. The respective wave lengths expressed in Ångström units* are:

Visible light ..	7,200–4,000 A.U.	The shorter the wave length, the greater the penetrating power.
Ultra-violet rays	4,000– 200 A.U	
X rays	500– 0·06 A.U.	

It was soon noticed that the parts chiefly affected by X rays were the face and eyes and dorsum of the hands. In the latter the effects were sharply delimited by the coat cuffs, showing that the clothing had in some way acted as a protective agent, although upon examination either by the fluorescent screen or by means of a photographic plate the clothing appeared to be quite transparent to the rays. It is now known that the clothing acts by cutting off the rays of longest wave length, which at the same time are the least penetrating and the most active in producing changes in living tissues.

The Pastille Dose.—The fact that undue exposure to the rays produces serious results upon the skin has made it essential that some means of gauging the dose given should be available. For this purpose the *Sabouraud pastille* is sufficiently accurate and is easy to use. It consists of a paper disc coated on one side with barium platino-cyanide. This, in its normal condition, is of pale apple-green colour, but with exposure to X rays it passes through a gradation of tints until it becomes brown. The amount of exposure which just results in a definite erythema also produces a given brown tint in the pastille, and this is known as a pastille dose and is taken as the unit of dosage. The exposed pastille is compared with a series of tinted pieces of glass in a tintometer, estimated to represent one-fourth, one-third, one-half, etc., of a pastille dose.

It must be clearly understood that this method, though convenient, is not scientifically accurate, since the 'softer' (less penetrating and with longer wave-length) rays are more active in producing this colour than are the 'harder' (more penetrating and with shorter wave length) rays. Needless to say, the Sabouraud pastille is useless to estimate the dosage of the very penetrating X rays used in deep therapy. For practical purposes screens of aluminium are usually placed between the X-ray tube and the patient, so as to cut off more or less of the softer radiations; they vary in thickness from 0·5 up to 6 or 8 mm. of aluminium.

One of the dangers in connection with X-ray therapy is that its effects upon the skin are not apparent at once; a certain latent period elapses between exposure and any obvious change, varying with the conditions and individual, but is generally from a week to fourteen days. If, therefore, a skin surface is irradiated, and the dose repeated before the time has elapsed for the former dose to have produced a reaction, a cumulative effect will result. A single exposure to an overdose may result in anything from a slight

* The Ångström unit (A.U.) $=10^{-8}$ cm. $=\frac{1}{100000000}$ cm.

transient erythema to a deep, painful, and slowly healing ulcer. Continued exposure of an area which has already been the seat of an X-ray burn may lead to the development of a definite carcinoma.

Among the lesser evils which affect the patient more than the operator are the production of bronzing and the formation of telangiectases, but these are largely due to idiosyncrasy. Some patients undergo repeated exposures—*e.g.*, at the site of an old mammary carcinoma, or on the neck for Graves' disease—without any marked result of this type; others, on the contrary, rapidly acquire a deep brown pigmentation, or a network of telangiectases may form. Whenever a slight erythema appears after irradiation, a soothing calamine lotion should be applied, and indeed in many places this is used as a routine preventive measure. It must, however, be remembered that this lotion or any application containing metallic salts must be thoroughly removed before the part is again irradiated, owing to the production of what are known as secondary radiations, when a beam of X rays impinges upon them. These secondary rays are of longer wave length than the primary, and may therefore have a destructive effect upon the tissues.

The therapeutic effects and uses of X rays will be noted in the ensuing section.

Radium.

Radium salts were first isolated from pitch-blende by Madame Curie in 1898, but the radium element itself not until 1911. For therapeutic purposes it is invariably employed in the form of one of its salts or as radium emanation. The radium salts commonly used are the sulphate, bromide, and chloride. The chloride and bromide are soluble in water, and can be obtained in the hydrated and anhydrous forms; the sulphate is insoluble, and is the salt generally used for filling radium applicators, as its insolubility is an obvious advantage in the event of any minute perforation occurring in the applicator.

Whatever salt of radium may be used, it is the radium element alone which is the active therapeutic agent, and hence it is always necessary when the haloid salts are in question to specify whether the hydrated or the anhydrous salt is meant. The percentage of radium element present in the different salts is as follows:

Salt.	*Percentage of Radium Element Present.*
Hydrated radium bromide ($RaBr_2 2H_2O$) ..	53·6
Anhydrous radium bromide ($RaBr_2$)	58·6
Hydrated radium chloride ($RaCl_2 2H_2O$) ..	67·9
Anhydrous radium chloride ($RaCl_2$)	76·1
Radium sulphate ($RaSO_4$)	70·2

In order to secure uniformity and to avoid any possibility of ambiguity, it is now the established rule to express radium dosages in terms of milligrammes of radium element; and radium applicators are now generally standardized so that their content corresponds to a given quantity of radium element. The total radium dosage

administered in any given time is expressed as 'milligramme hours,' *i.e.* the number of milligrammes of element used multiplied by the number of hours during which the application was made.

Radium itself is a metallic element belonging to the barium group, and the radiations from a radium salt are complex, but have been recognized as falling into three groups, originally distinguished by variations in their penetrating power, but now shown to be fundamentally different in their nature.

The α particles are doubly positively charged helium atoms, which are given off with a velocity of about 0·1 to 0·3 of the velocity of light.* Their penetrating power is, however, exceedingly small, since they are stopped by a screen such as a sheet of paper or a millimetre or less of epithelium. Since radium salts are, for surgical purposes, always enclosed in containers, it is clear that the α particles take no part in the therapeutic action; from the purely scientific aspect they have, however, been of paramount importance in elucidating the problems of atomic structure, while they represent no less than 92·7 per cent. of the total radiant energy given off from a salt of radium.

The β particles are electrons, or unit charges of negative electricity associated with a mass of $\frac{1}{1850}$ that of a hydrogen atom, while the most rapid among them have a velocity closely approaching the velocity of light. Roughly speaking, they may be regarded as having a penetrating power about a hundred times as great as that of the α particles. They are, however, screened off by relatively thin layers of various metals. As regards their action on the tissues, it may be best described as indiscriminately destructive, and, when sufficiently intense, may give rise to radium necrosis with its obvious constitutional symptoms. For most surgical purposes, therefore, the β radiations are purposely cut off by metal screens of suitable thickness. The thickness of different metals necessary to screen off 50 per cent. or 99·9 per cent. respectively of β rays may be summarized as follows:

Substance.	*Thickness Necessary for Absorption of—*	
	50 per Cent. Radiations.	*99·9 per Cent. Radiations.*
Monel metal†	0·15 mm	1·5 mm.
Silver	0·13 mm.	1·3 mm.
Lead	0·12 mm.	1·2 mm.
Gold	0·07 mm.	0·7 mm.
Platinum	0·06 mm.	0·6 mm.

* The velocity of light is 3×10^{10} cm. per second, or about 186,000 miles per second.

† Monel metal is an alloy largely used for some forms of applicator, in consequence of its hardness and durability. Mr. Pearce, director of Chemical Service Company, Ltd., has stated that its composition usually is 60 per cent. nickel, 2 per cent. manganese, balance electrolytic copper, and in some cases 5 per cent. aluminium is used.

The γ rays are electromagnetic waves akin to the ultra-violet and X rays. Their velocity is the same as that of light, but their wave length is generally much shorter than that of X rays. The shorter the wave length of either X rays or γ rays, the greater is the penetrating power of a beam of X or γ rays is an inverse function of its wave length.

It is the γ rays which are mostly used in radium therapy, and that because they appear to have a selective action in destroying malignant cells more readily than the normal cells of the body. It is, moreover, held by some authorities that this selective action is most marked in the γ rays of shortest wave length (*i.e.*, the 'hardest' γ rays), and to this end the screenage is often increased. As we have seen, a screen of 0·6 mm. of platinum cuts out 99·9 per cent. of the β radiations; at the same time, however, it also cuts out a proportion (about 6 per cent.) of the γ rays. With increasing thicknesses of platinum the proportion eliminated is increased, while the proportion allowed to pass comprises the rays of greatest hardness or shortest wave length.

As regards the form of radium applicators, for surgical lesions, these often take the form of flat applicators of different shapes and sizes, adapted to the purpose for which they are intended. Applicators for surgical use are mostly made on the form of hollow needles, or tubes with a wall thickness of 0·5 mm. of platinum-iridium alloy.* Tubular applicators can, in many cases, be used as flat applicators by suitably placing a number of them side by side, mounted according to circumstances on a strip of adhesive plaster, or when required, for example, for intraoral application, on a plate or denture of dental wax. Whatever the shape of metal applicator used, it is absolutely essential that in no circumstances whatsoever should it be allowed to come in contact with any mercurial salt, either in lotions or dressings, otherwise amalgamation and consequent perforation will result. A similar caution applies to the use of iodine.

Radium emanation or radon, the radioactive gas given off from radium, is also employed in radiation therapy. It is impossible to deal here with the subject of atomic disintegration, and the types of radiation emitted during its various phases. Suffice it to say that for obtaining radon for therapeutic purposes, a soluble salt of radium (the chloride or the bromide) is dissolved in acidulated water, and the resulting radioactive gas (radon) pumped off and purified in a suitable apparatus, whence it can be collected and sealed off in suitable capillary glass tubes. These can be directly inserted into the tissues or enclosed in thin platinum tubes (0·5 mm. in thickness) before insertion (Fig. 92). The object of this screenage is the elimination of β radiation, and the consequent avoidance of the necrosis,

* *I.e.*, platinum to which 10 per cent. of iridium is added to increase the durability, hardness, and rigidity of the tubes. Pure platinum bends too easily, and tubes with a wall thickness of less than 0·5 mm. are insufficiently rigid to be generally convenient for surgical purposes.

sloughing, and pain which attend the action of β radiations upon the tissues.

For the preparation of radon for therapeutic purposes a relatively large quantity of radium salt is necessary; at the Medical Research Council's radon centre at the Middlesex Hospital about a gramme of radium bromide is used, and smaller quantities are not of much practical use for the purpose. The radium salt, when being used for the production of radon, can obviously not be put to any other use. A further point in connection with the use of radon is that, when separated from the radium salt which produced it, it undergoes a progressive diminution of activity.

Radium itself undergoes spontaneous disintegration at such a rate that a given sample would be reduced to half its value in 1,690 years; for practical purposes it may thus be regarded as indestructible. Radium emanation, on the other hand, disintegrates at such a rate that a specimen reaches half its value in 3·85 days. From this it is obvious that when a tube containing, say, the equivalent of 1 milligramme of radium element is inserted into a tumour for any length

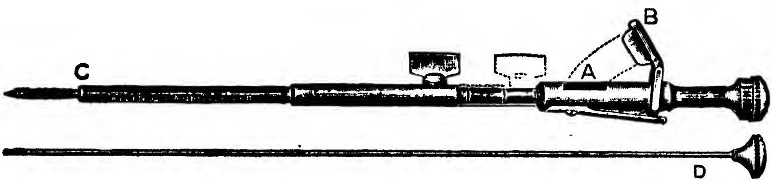


FIG. 92.—RODON SEED INTRODUCER.

The seeds are placed in the slot A and forced into the tube by pressing down the handle B after the trocar C has been withdrawn. The seeds are then forced along the introducer into the tissues by the ramrod D.

of time, the radiation emitted is constant. When, on the other hand, a tube containing radon is used, the intensity of the radiation rapidly falls off, and this is one of the disadvantages of the use of radon in these times when prolonged radiation, *i.e.* for such a period as seven to twenty-one days, has been found to be the most successful method of irradiating neoplasms.

The rate of decay of radon, when separated from the radium which gave rise to it, is summarized in the following table:

Days.	*Percentage of Initial Activity.*	*Days.*	*Percentage of Initial Activity.*
0	100·00	9	19·70
1	83·50	10	16·50
2	69·70	12	11·50
3	58·20	14	8·00
4	48·60	16	5·60
5	40·60	18	3·90
6	33·90	20	2·70
7	28·30	24	1·30
8	23·60	30	0 45

The Choice of Radium or Radon as a Therapeutic Agent.—Since the supply of radon from a given supply of radium salt is practically inexhaustible, it follows that the gas, when separated from the parent radium, has but slight intrinsic value, so that no financial loss is to be apprehended from possible loss of the tubes. Moreover, the radium which is the source of the radon used will be kept in a safe place. The disadvantages attending the employment of radon are:

(*a*) A large amount of radium is necessary for its preparation, and this can be used for no other purpose.

(*b*) A highly trained and skilled staff is required for carrying out the procedures necessary for its purification and separation.

(*c*) Radon disintegrates so rapidly that it is unsuitable for some of the prolonged exposures which are such a feature of modern radium surgery.

The only disadvantage attending the use of radium as distinguished from radon is the very high intrinsic value of applicators containing even only fractions of a milligramme, and the consequent risks of loss.

The unit of radium emanation is known as the *Curie*, and denotes the quantity of the gas in equilibrium with 1 gramme of radium. The volume of radon corresponding to a *Curie*, measured at 0° C. and 760 mm. pressure, is very small—namely, 0·6 cubic millimetre. For most practical purposes the *Curie* is too large a unit, and its thousandth part, the *millicurie*, is used instead. One gramme of radium element in solution (*i.e.*, as one of its soluble salts) will give practically about 150 millicuries of radon, capable of utilization for therapeutic purposes in twenty-four hours.

It is not too much to say that since the last edition of this book was published, radium therapy for malignant disease has undergone what is practically a revolution. This is due to the technique of using a number of tubular applicators, each containing a small amount of radium element, and allowing them to remain *in situ* over relatively prolonged periods (say, seven to twenty-one days), whereas the older practice had consisted in the insertion of relatively large amounts of radium with a short period of application. The insertion of radium applicators has thus become a recognized piece of surgical technique, wherein the objects aimed at are, firstly, a uniform irradiation of the neoplasm itself; and, secondly, a uniform control of possible areas of lymphatic dissemination. It is true that remarkable results have been attained by this means, but it is a fatal error to regard radium as a panacea for malignant disease in all its forms, and as ousting operative procedure as the method of choice in all cases. In this connection the weighty and well-considered words which occur in the Report of the Medical Research Council for 1928 may well be commended to the reader's attention:

'The position now is that there is scarcely any part of the body likely to be the seat of cancer for which some method of applying radium has not been devised. Nothing, however, could be more

fallacious than a belief that this development of technique constitutes a proof of the utility of radium in every form of cancer. The enthusiasm which is apt to attend the introduction of every new radiological method is inevitably followed by the sobering influence of statistical data as to the state of patients one, two, three and more years after they have received treatment.

'The Committee think it important to emphasize this aspect of the whole subject of radium therapy in cancer, for while it is true that there is good warrant for an extended use of radium in many forms of the disease, it is no less true that the general expectation of the public as to what can be achieved is likely far to outrun the probabilities.

'Radium should at present be looked upon as an agent for the treatment of localized cancer, and the more limited the region affected the more chance there is of success. Once the disease is generalized the use of radium is mainly palliative. This view is well exemplified in the treatment of cancer of the uterine cervix. If a cancerous growth be so limited in extent as to be called operable, then it can most probably in proper hands be eradicated by the means of radium. If extension of the disease from the primary focus make the disease inoperable, radiation methods may still do successful work, but only if the treatment is so planned that the limitations of the effective zones of radiation are visualized no less surely than the probable paths of extension of the disease. If there are metastases radiological methods generally fail.

'Similarly in cancer of the tongue, a localized primary growth in any part can be treated with radium with a good prospect of success. If the glands on either side of the neck are affected, however, radiation methods are tested to their utmost to deal with these extensions, and this is reflected in the present lack of unanimity as to the best method to adopt for them. Again, with wide extensions of the disease beyond glands near to the primary focus, radiological methods are at present generally unsuccessful.'

Another development of radium therapy is treatment by what is known as the 'radium bomb.' For this purpose a large quantity (equal to 4 or 5 grammes of radium element) is enclosed in a suitable lead container furnished with a window, through which the γ rays can pass, and thus be directed on to the patient. Owing to the small quantities of radium hitherto obtainable in this country, this method has as yet had but little chance of trial, and generally the tubular applicators are those commonly used for surgical purposes.

In the earlier days of radium therapy it was often a vexed question whether surgery or radiation treatment was to be preferred in any given case. At the present time the position is somewhat changed, and the question in the treatment of neoplasms is rather what combination of surgery and radium therapy is likely to be the most efficacious. Two advantages may be fairly classified for radium surgery:

(1) The limitation of extent of the operation.

(2) Generally speaking, the introduction of radium is devoid of any operative mortality.

The actual results of radium or X-ray treatment cannot be discussed *in extenso* in this book, but one or two facts and general principles may not be out of place.

(*a*) **Superficial Lesions.**—Many forms of superficial growth are effectively and satisfactorily treated. Warts, nævi, keloids, and other similar non-malignant growths are often cured by three or four applications of radium, and sometimes even by one application. Rodent ulcers often give remarkable response. It is, however, necessary to caution the patient—even when the lesion is apparently cured—to return for inspection should there be the smallest suggestion of recurrence. If a rodent ulcer does not respond well to radium, it is generally desirable to resort to surgery, as continual irradiation of an intractable rodent ulcer may lead to the development of a typical squamous-cell carcinoma.

Both radium and X rays have been employed in the treatment of lupus, and good results have been claimed. It is also true that very serious complications have followed this treatment, and one of our most eminent dermatologists expressed it as his opinion that the use of X rays in lupus was nothing more nor less than criminal. A patient who was seen during the past year had been treated for lupus of the face by repeated doses of X rays. The result has been the development of a spreading squamous-cell carcinoma which has already involved the loss of the nose and of one eye, and is rapidly passing out of control.

(*b*) **Carcinoma of the Breast** has also been treated merely by the surgical introduction of a number of radium needles, arranged to irradiate the neoplasm itself and also to control the different lymphatic channels. The containers used are individually of small radium content (2 or 3 mgm. of radium element). The radium is left in position for at least a week, and for ten days if the tumour is large. Here good results are claimed, but it will be necessary to wait for some years before a comparison can be made with purely operative measures. Recurrence after apparently successful operation may occur twenty-five years subsequent to amputation of the breast. One thing is, however, definite—namely, that the operative procedure is reduced to a minimum, and there is no removal of the pectoral muscles.

(*c*) In **Carcinoma of the Tongue** and buccal cavity good results have been recorded from the insertion of small amounts of radium for a considerable period. The growths which show themselves most amenable to such treatment are those which exhibit the least differentiated type of epithelial formation. It is unfortunately this very type of growth which is most malignant as regards metastatic spread. Obviously such growths require early diagnosis and prompt treatment. Growths showing a high degree of epithelial differentiation, though less malignant than the less differentiated forms, are, however, less susceptible to the action of the rays.

(*d*) **Carcinoma of the Rectum** has also been treated by combined radium and surgery. In this case, however, the preliminary operation of access is definitely severe.

The results appear to have been encouraging, but carcinoma of the rectum is itself not much more sensitive to the rays than is the normal rectal mucosa. Preliminary colostomy is also necessary in order to avoid sepsis as far as possible, since septic changes militate against successful radium treatment.

CHAPTER XII.

HÆMORRHAGE.

BY the term *hæmorrhage* is meant any escape of blood from the vessels, whether insignificant and immediately arrested by natural means, or more excessive and requiring treatment to prevent its continuance. Although most commonly due to traumatism, it may occur in certain diseases, such as purpura and scurvy, without apparent reason; whilst in hæmophilia there is a congenital lack of coagulable power, so that it is difficult to stop any flow of blood when started.

Arterial Hæmorrhage consists in a flow of bright red blood, which escapes at first *per saltum*—*i.e.*, in jets synchronous with the heart's beat—and may be derived, not only from the proximal, but also from the distal end of the divided vessel, if the collateral circulation is sufficiently abundant. If, however, it is derived from a deep artery, the blood may well up from the depths of the wound and not escape in gushes. In **Venous Hæmorrhage** the flow is usually continuous, and the blood of a dark red or almost black colour. If, however, a large vein is wounded, such as the internal jugular, the blood may escape with a very definite spurt, owing to respiratory or other influences. **Capillary Hæmorrhage** is marked by general oozing from a raw surface, the blood trickling down into a wound, if present, and filling it from below upwards. By **Extravasation of Blood** is meant the pouring out of blood from a wounded vessel or vessels into the lax areolar planes immediately adjacent, which become swollen and boggy. The usual constitutional signs may be manifested as a result of such extravasation, and fatal hæmorrhage may even occur in this way without any escape upon the surface of the body. Subcutaneous or submucous hæmorrhage is also met with in the form of small localized **petechiæ**, arising from injuries, or from changes in the blood or vessel walls (as in purpura, scurvy, and septicæmia). **Epistaxis** is the term given to bleeding from the nose. By **Hæmatemesis** is meant the vomiting of blood; it may either have been swallowed, as in some cases of fractured base of the skull, or it may have originated from the upper part of the intestinal tract. If it has remained in the stomach any length of time, the blood becomes curdled and brownish in colour, somewhat resembling coffee-grounds, from the action of the

gastric juice upon it. When gastric hæmorrhage is more active, the blood is bright red in colour, and may be vomited in the form of large clots. **Hæmoptysis** is the title given to the escape of blood from the air passages, whether it results from injury or disease. In the milder cases it is usually bright red and frothy from admixture with air; in graver cases, when larger vessels are involved, the blood may escape unaltered, and be so abundant as to asphyxiate the patient. **Hæmaturia** (*q.v.*) is a condition in which blood is passed in the urine. By **Melæna** is meant the passage of dark tarry blood with the fæces; it is always an evidence of disease or injury of the intestinal canal sufficiently far from the anus to allow the blood to become altered in character by the action of the intestinal juices. Blood derived from the rectal mucous membrane usually retains its bright red colour.

The **Constitutional Effects** of hæmorrhage are twofold: (1) There is a loss greater or less of the fluid content of the blood, but this is readily and rapidly made good within certain limits by the withdrawal of lymph, etc., from the tissues generally. The blood-pressure falls, but unless the loss is great it quickly rises to the normal after the bleeding has ceased; this restoration is due partly to a diminution of the vascular area, owing to vasomotor contraction of the peripheral arterioles, but also to the rapid absorption of lymph from the tissues already mentioned. In severe cases, especially when shock is superadded, the blood-pressure may remain low. (2) An even more important loss is that of the red cells with their oxygen-carrying hæmoglobin; hence, after a severe hæmorrhage the supply of oxygen to the tissues is defective, and this may be of serious import in cases of shock. For the changes that occur in the blood as a result of hæmorrhage, see p. 46.

Children and elderly people alike bear the loss of blood badly; but whereas children rapidly recover from the immediate effects, elderly people do not.

If the hæmorrhage is severe, as from division of a large artery, death results from syncope. The surface of the body becomes cold, clammy, and pale; the lips, ears, and eyelids are livid; the patient gasps, his respirations become quick and sighing, and death ensues after perhaps a few convulsive twitches of the limbs.

If the hæmorrhage is not so great as to kill immediately, the patient faints, and on recovery is in a condition of severe collapse and weakness, which continues for some time; he is also liable to recurrent attacks of syncope, especially if the bleeding persists.

If the hæmorrhage is *concealed* and of moderate severity, as from ulceration of the stomach or duodenum, or by slipping of a ligature after an abdominal operation, the patient rapidly becomes profoundly anæmic, and his face shrunken and drawn as a result of the dehydration of the tissues of the cheeks. The organs of the body generally suffer from want of oxygen, and hence the patient feels as if he were being suffocated, and is extremely restless, tossing

about in bed, and clamouring for open windows and more air (*air-hunger*). Any sudden exertion, or even sometimes the attempt to sit up, is followed by a sensation of faintness or actual syncope; noises are heard in the ears, the sight becomes dim, or is even temporarily lost (amblyopia), and severe headache may be complained of, all arising from cerebral anæmia. The pulse often becomes what is known as *hæmorrhagic* in character—*i.e.*, frequent and compressible, but collapsing entirely between the beats, and markedly dicrotic; this is due to the sudden passage of a small amount of blood through a vessel which is practically empty.

General Treatment.—When the loss of blood has been severe, the patient must be kept quiet with the head low, whether syncope is present or not. The foot of the bed or couch should be raised, so as to assist in the maintenance of the circulation to the medullary centres. *Stimulants* may be necessary to maintain the heart's action, but *should never be given until the bleeding has been effectively controlled,* as otherwise they may increase or restart it. If death appears to be imminent, the arms and legs should be bandaged, or the abdominal aorta compressed, in order to confine the blood as much as possible to the head and trunk.

'No patient should be allowed to die of hæmorrhage.' Such was the dictum of the late Mr. Wooldridge, of Guy's Hospital, based on a knowledge of the value of transfusion and infusion. By **transfusion** is meant the transference of blood from one individual to another; its value and methods of employment have been already described (p. 54).

In milder cases of hæmorrhage all that is required is to restore the amount of fluid lost by the introduction into the circulation of a corresponding quantity irrespective of its quality, so long as it is harmless and can mix with the blood-plasma. **Infusion** of an isotonic salt solution is therefore capable of giving excellent results in suitable conditions. If the veins are or can be sufficiently distended, a metal needle is inserted into one subcutaneously, and through it two or three pints of the solution can be injected; but if, as is often the case, the veins are collapsed, an incision has then to be made over some suitable vein (*e.g.*, the median basilic or cephalic, *just above* or below the flexure of the elbow, so that subsequently the scar shall not be troublesome), which is exposed and its distal end tied. A ligature is passed under the proximal end, and by exercising traction upon this the vein is temporarily kinked and loss of blood prevented. A longitudinal or oblique slit is then made in the vein, and the cannula, filled with the fluid so as to exclude all air, inserted; a half-knot tied around the cannula will prevent it from slipping. When the necessary amount of fluid has been introduced, the cannula is withdrawn, and the knot around the proximal end of the vessel completely tied. The amount injected varies with circumstances, but two or three pints are usually required; in case of need the process may be repeated, but rectal infusion will often suffice in the later stages.

As to the material, a warm saline solution is the best, consisting of a drachm of chloride of sodium to a pint of sterilized water (or about 0·65 per cent.), at a temperature of 105° to 110° F. Tablets of the dried salt are dissolved in a small quantity of boiling water, and this is then diluted to the required bulk and temperature. Of course, the apparatus is carefully sterilized, and no air must be admitted. The injection is made slowly, so that the solution may be mixed gradually with the blood. It has been found by experiment that after an infusion following hæmorrhage the specific gravity of the blood is only lowered for a very short period, and rapidly rises to a normal level, or may even be raised above the normal. This suggests that the increased amount of fluid is absorbed into the tissues, and explains why it is sometimes necessary to repeat the injection more than once.

Fluid may also be introduced into the body through the rectum (*proctoclysis*), or through an exploring needle connected with a tube and funnel into the loose connective tissues of the buttock, abdomen, or submammary region (*hypodermoclysis*). In the latter case the funnel or receiver must be held at some height (5 or 6 feet), in order to gain sufficient pressure, and by this means a pint or more may be slowly injected; a carefully sterilized syringe and a large needle may be employed for the same purpose. During the injection the part should be gently rubbed so as to distribute the fluid. Absorption is fairly rapid, but occasionally in debilitated and septic subjects sloughing and suppuration occur at the site of infusion, especially if the most careful precautions as to asepsis have not been taken. For methods of proctoclysis, see Chapter XXXVIII.

Natural Arrest of Hæmorrhage.—The process is much the same for arteries, veins, or capillaries; but since the arrest of arterial hæmorrhage has been more thoroughly investigated, and is the most important, we shall deal mainly with it.

The **Temporary** arrest of arterial hæmorrhage is brought about by three principal factors:

(1) The **coagulation of the blood,** which occurs in and around the vessel, and without which death would ensue from the merest scratch. The coagulability of the blood varies in different subjects, and is influenced by various conditions—*e.g.*, the amount of calcium salts present. In hæmophilia the blood coagulates with difficulty, and therefore hæmorrhage is always a serious phenomenon. Loss of blood increases the coagulability to a certain degree.

(2) **Diminution in the force of the heart's action** always follows hæmorrhage from anæmia of the cerebral centres, and thereby coagulation is facilitated and the flow of blood checked.

(3) **Changes in and around the vessel** play a most important part in completing the process. They consist in the **retraction of the artery within its sheath by reason of its inherent longitudinal elasticity; if, however, it is only divided partially (or, as it is called, 'button-holed'), this condition cannot obtain, and the hæmorrhage**

is more likely to continue. As a result of this retraction, the rough and uneven inner lining of the sheath is exposed, and upon this the blood coagulates as it flows, thus gradually producing what is known as the **external coagulum.** At the same time the transverse muscular and elastic fibres in the vessel wall cause **contraction** of the open mouth, and thereby the external coagulum is able to increase in size by fresh deposits of fibrin, until at last its resistance is too great for the diminished cardiac impulse to overcome, and the sheath is filled with clot, which extends to the divided mouth of the vessel. From this an **internal** coagulum occasionally develops, extending upwards as far as the nearest patent branch.

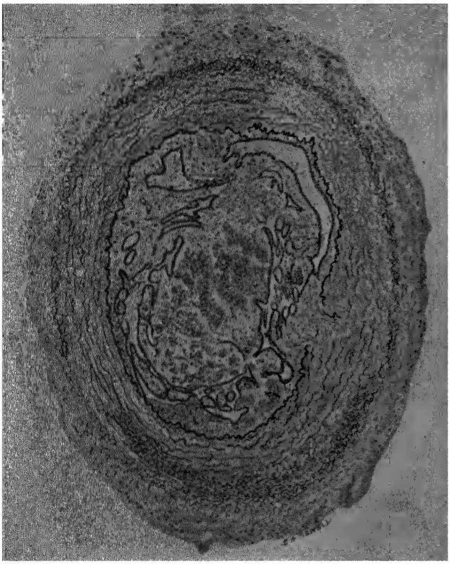


FIG 93 —ORGANIZATION OF THROMBUS IN ARTERY. (AFTER MACCULLUM)

The clot has become vascularized, and in parts is almost canalized. The thrombus has practically disappeared, and is replaced by granulation tissue undergoing organization, its origin from the tunica intima is clearly indicated.

The **Permanent** closure of the wound in the artery is brought about by a modification of the general process of repair. When the escape of blood has ceased, the arterial wall contracts upon any clot which may be present. As a result of the injury a simple arteritis is set up, evidenced by a hyperæmic condition of the vessel wall and its infiltration with leucocytes which also attack the coagulum, breaking it up and traversing the natural lines of cleavage which result from its contraction, and gradually remove it, a few giant cells sometimes assisting in the process. The endothelial cells of the tunica intima proliferate, leading to a secondary infiltration of the thrombus with large fibroblastic cells which, with the addition of capillaries derived from the vasa vasorum, convert the affected portion of the vessel wall into a rod of granulation tissue (Fig. 93), and this in due course is transformed into cicatricial tissue, which finally replaces the divided vessel. Similar changes occur in the distal end of an artery tied in its continuity. The ligature itself is infiltrated by leucocytes and absorbed, or it may be encapsuled. The presence of a coagulum is no essential element in this process, for if the

arterial walls are merely drawn together by a ligature so as to be in apposition, a similar occlusion results.

The arrest of hæmorrhage from veins and capillaries is more easily accomplished, the collapse of the walls and the absence of blood-pressure facilitating the process. The later steps are similar to those occurring in an artery.

Surgical Treatment of Hæmorrhage.—Many different methods are needed for the effective arrest of hæmorrhage. It may be laid down as a preliminary axiom that *digital pressure over the bleeding-point will always check temporarily the most furious outburst*, whilst means for its permanent stoppage are being arranged.

Where the bleeding is general and does not come from any one particular vessel, the following measures can be utilized:

1. **Position.**—When the bleeding is from one of the extremities, especially the lower, elevation by emptying the veins will determine a reflex contraction of the arteries, and thereby assist hæmostasis.

2. **Cold** may be employed in the form of ice, cold water, or lotion, or simple exposure to the air, all clots, swabs, pledgets, etc., being removed for this purpose; it must, however, be remembered that ice and unsterilized water may convey infective germs. Such treatment is of most value for general oozing from vascular structures or into cavities, such as the mouth, vagina, or rectum.

3. **Hot Water** (130° to 160° F.) is a powerful hæmostatic. It is supposed to act by stimulating the involuntary muscular fibres of the vessel wall; but probably the coagulation of the albumin of the blood is an important factor, as unless the water is hot enough to blanch the surface of the wound, the bleeding is not stayed, but rather encouraged.

4. **Cauterization** is but little employed as a hæmostatic, except for the bloodless removal of vascular tumours by one of the various forms of cautery (p. 307). Occasionally, however, it is used for bleeding from tissues which are infiltrated and thickened by chronic inflammation so that a ligature cannot be applied. In order to seal effectually the mouths of the vessels, the cautery must be at a dull red or black heat; a bright red-hot iron cuts through a vessel as cleanly as a knife, and does not stop the hæmorrhage.

5. **Chemical Agents** may be used to assist in checking hæmorrhage from spongy tissues, or from deep cavities or organs. (*a*) They may act locally as *styptics* by causing direct coagulation of the blood—*e.g.*, liq. ferri perchloridi or pernitratis, tannic or gallic acids, alum, nitrate of silver, styptic colloid, etc. In employing these, the surface of the wound must be cleansed and dried as far as possible, and the styptic then applied on lint or gauze. Unfortunately, the more active, such as liq. ferri perchloridi, are actively caustic, and may cause sloughing; it is seldom that such applications are necessary. (*b*) They may increase the coagulability of the blood, and of these lactate of calcium is the most effective. It is usually administered *per rectum* in a small enema containing

15 grains, and this may be repeated two or three times in a day. The use of this drug before operations which are expected to be very sanguinary has been most satisfactory in many cases. (*c*) They may be effective as *vaso-constrictors*, and of these the chief is adrenalin. It is probably more valuable in preventing than in checking hæmorrhage, and is largely used in intranasal work; it is prepared in the dry form, since it loses its power when kept in solution more than an hour or two. The addition of cocaine to its solution increases its activity. Its effect is, however, very temporary, and provision must be made to control reactionary bleeding when its influence ceases. (*d*) A large class of drugs of the astringent class are employed empirically under varying circumstances to assist in hæmostasis—*e.g.*, turpentine, hamamelis, ergot, acetate of lead, etc.—but it cannot be said that their action, though appreciated, is fully understood. (*e*) Finally, it is most important in cases of internal hæmorrhage, as from the lungs or gastro-intestinal canal, to keep mind and body quiet, and there is no agent under these circumstances more valuable than *opium* and its salts.

6. **Direct Pressure,** as already mentioned, when available, is always effective—at any rate, for a time. General oozing from cut surfaces, which can be brought into apposition, as in an amputation wound, may be checked by applying a firm bandage over them. In cavities or hollows, either natural or made by operation, bleeding may be stopped by packing with strips or graduated layers of sterilized gauze or lint. Such dressings should be retained firmly in position for twenty-four hours, after which, if no further hæmorrhage has occurred, the bandages may be slackened; but it is usually advisable to retain the deep plugs for another day or two.

When the bleeding is more serious, and originates from some definite vessel or vessels, more precise measures have to be adopted. Digital pressure over or on the cardiac side of the bleeding spot suffices to arrest it for a time, whilst preparations are being made to secure the wounded vessel.

1. **Forcipressure** is a plan for stopping hæmorrhage by crushing the divided end of the vessel between the strong and deeply serrated blades of a pair of forceps with scissor-handles provided with a catch; those known by the name of Spencer Wells, Kocher, or Greig-Smith are the most convenient. In dealing with small vessels, it is quite sufficient to leave the forceps applied for a few minutes, perhaps twisting them before removal; but with the larger it is advisable to apply a ligature, although it is claimed for the Greig-Smith pattern that the artery is so thoroughly crushed that this is unnecessary. In deep wounds, where it is difficult, or almost impossible, to tie the vessel, the forceps may be incorporated in the dressings, and not removed for twenty-four hours or longer.

2. **Torsion** is still occasionally employed for small vessels after forcipressure, and is specially useful in skin-grafting. The effect

is to cause rupture of the inner and middle coats just above the spot grasped, and these curl upwards into the lumen of the vessel, whilst the outer coat is twisted up beyond. A coagulum forms upon the injured structures, and the subsequent processes to secure permanent occlusion are similar to those described above.

3. **Ligature** is at the present day the method most frequently used for arresting bleeding from a definite source.

The **material** should be of sufficient strength to secure the vessel, of sufficient resistance to maintain its hold in spite of being soaked in the body fluids, and yet of such quality as to be absorbed, or so pure and unirritating as to become encapsuled in the tissues. *Catgut* suitably prepared is generally employed. It is obtained from sheep's intestines by allowing them to putrefy in water, and then scraping away the mucous and muscular coats, leaving only the elastic basement membrane of the submucosa; this is dried and twisted into the long strands of commercial catgut. When soaked in blood-serum, this substance swells up into a soft, pulpy mass in half an hour, so that it is necessary to harden and render it more resistant before use, as well as to sterilize it thoroughly. It is most effectively prepared by immersion in a mixture of chromic and sulphurous acids in accordance with Lord Lister's original instructions.* The length of time that catgut remains unabsorbed in the tissues varies with the length of its stay in the chromic acid solution, and material calculated to last ten, twenty, thirty, or forty days and suitably sterilized can be obtained from instrument makers. (See also on p. 293.)

FIG 94 [illegible] ING A LIGATURE FIRMLY AROUND AN ARTERY.

The ligature was tied at two levels, and the artery then laid open longitudinally.

Sterilized silk and linen thread are also employed, but not being absorbable, should be avoided in septic cases, as they are almost certain to slough out under such circumstances, and may cause much trouble.

The immediate *effect* of a ligature *on the arterial wall*, if the vessel has been tied in the usual way, is to divide the inner and middle coats, which are separated from the outer, and curl up slightly, whilst the outer coat is constricted and thrown into folds within the grasp of the ligature (Fig. 94). If an artery is tied in its continuity, the same effect is produced on each side of the ligature. The changes already described, by means of which the artery is obliterated and transformed into a fibro-cicatricial cord, manifest themselves in due order. If the ligature, however, is *infected* and irritating, it has to cut its way out through the vessel wall by an

* *Brit. Med. Journ.*, January 18, 1908.

ulcerative process akin to the separation of a slough, thus exposing the patient to the risk of secondary hæmorrhage.

Division of the inner and middle coats is not an essential element in gaining satisfactory occlusion of a vessel, for it can also be effectively accomplished by merely bringing the vascular tunics into close approximation by means of a ' stay knot ' (p. 368).

Arterial Hæmorrhage.—Three forms are described—viz., primary, reactionary, and secondary.

I. **Primary Arterial Hæmorrhage** is met with from an open wound, or where an artery is ruptured or punctured subcutaneously, so that extravasation occurs into the tissues.

A. **From an Open Wound.**—The blood is here poured forth upon the surface, and escapes freely.

The *principles* that guide us in its **Treatment** may be enunciated as follows:

1. *The vessel must be secured at the bleeding-point*, an operation to expose it being undertaken if necessary. However infiltrated the part, the rule of cutting down to expose the wounded vessel is to be adhered to, and this for two reasons: (*a*) It is often impossible to know the exact source of the hæmorrhage unless it is laid bare. Thus, the bleeding from a punctured wound of the front of the leg, which was apparently derived from the anterior tibial artery, was proved on incision and careful dissection to come from the peroneal, the wound extending backwards between the bones. In the axilla and groin such uncertainty often exists. (*b*) Proximal ligature is often insufficient to arrest the hæmorrhage, since the collateral circulation is quickly established. In one or two regions, however, such as the palm of the hand, the sole of the foot, or the pterygoid region, the dissection to expose the bleeding-point may be so difficult and dangerous, or so likely to be followed by damaging adhesions. that the above-mentioned rule is sometimes departed from and proximal ligature undertaken.

2. *Both ends of the wounded vessel must be secured* if it is completely divided, whilst if it is only punctured, a ligature must be placed on each side of the puncture, and the complete division of the vessel effected. As a rule the collateral circulation is quickly established,

3. It is *only needful* to undertake the measures detailed above in cases *where primary hæmorrhage is actually proceeding*. If it has been once arrested, it is unnecessary to search for the bleeding spot, unless the patient is very faint and collapsed, and the surgeon has reason to anticipate that a large trunk has been injured, when it may be needful to seek for and tie it at once; otherwise, recurrent hæmorrhage is likely to ensue when the heart's action becomes more vigorous.

In the actual bleeding of any particular case, **temporary arrest** of the bleeding may usually be effected *by digital compression* either of the bleeding-point or of the main trunk at a favourable spot nearer to the heart, against some resisting structure, such as a sub-

jacent bone. The *common carotid* is controlled by grasping the neck from behind, and compressing the artery by the fingers placed along the anterior border of the sterno-mastoid against the transverse process of the sixth cervical vertebra (Chassaignac's tubercle). Such pressure will also control the vertebral and inferior thyroid vessels. The *subclavian* is to be compressed in the third part of its course against the first rib by the finger or thumb placed immediately behind the clavicle, in the angle between it and the sterno-mastoid, the pressure being made downwards and inwards. A good deal of force is sometimes required in order to maintain the pressure, and this may be gained by superimposing the fingers or thumb of the other hand. When the pressure is to be kept up for some time, the padded handle of a door-key may be employed in the same way. The *facial* artery is compressed against the lower jaw just in front of the masseter muscle; the *temporal* artery, against the zygoma just in front of the ear; the *occipital*, at a spot about 1½ inches from the occipital protuberance against the superior curved line. To control the *brachial* artery, the arm should be grasped from behind, and the fingers pressed inwards along the inner margin of the biceps against the humerus. The *abdominal aorta* is controlled in slim individuals with ease by pressure through the abdominal wall against the body of the third lumbar vertebra a little above and to the left of the umbilicus—*i.e.*, just above its bifurcation; in stout persons this is impossible. The *common femoral* artery is best compressed immediately below Poupart's ligament. The surgeon should stand on the same side of the patient as the artery to be controlled, and use the finger-tips to press the vessel directly backwards against the pubic ramus. The fingers of one hand placed over the other are sometimes needed to maintain sufficient command.

As digital compression cannot, however, be comfortably maintained for long, *mechanical compression* of a limb, as by a tourniquet or elastic bandage, must be requisitioned. A useful contrivance in cases of emergency is fashioned out of a large handkerchief, which is knotted loosely round the limb, and tightened by the rotation of a piece of wood inserted beneath it; a pad is also placed over the main artery, which is thereby compressed.

The wound is then, if need be, enlarged by incisions, which, whilst laying the parts freely open, should inflict the least possible damage on surrounding structures. All coagula are removed, the parts are purified, and a search made for the wounded vessel. It may be needful to relax the tourniquet, and allow a jet of blood to escape, in order to ascertain its position. Both ends should be sought for and tied, a proceeding often easier said than done. This especially applies to the distal end, which retracts, and possibly does not bleed at the time of operation.

B. For **Subcutaneous Rupture of an Artery,** see p. 340.

II. **Intermediate or Reactionary Arterial Hæmorrhage** is the term applied to bleeding which recurs within twenty-four hours of an

accident or operation. It may result from two chief causes: (*a*) Defective application of a ligature, which comes undone from being badly tied (a 'granny' knot), or slips off from including within its grasp other structures as well as the arterial wall; or (*b*) the coagula lying in the mouths of divided and unsecured vessels are not sufficiently firm to withstand the increasing blood-pressure which supervenes after the shock has passed away, or which may be due to excitement or the injudicious administration of stimulants. It is usually not very serious, inasmuch as it can only arise from the smaller vessels, all the larger ones having probably been recognized and tied during the operation. Dense structures, such as scar tissue or the parenchyma of the mamma, are favourable sites for the development of reactionary bleeding.

Treatment.—Elevation and the pressure of a firm bandage are often quite sufficient to arrest this form of bleeding; but if unsuccessful, the wound must be opened up, washed out with hot salt solution, and any bleeding vessels tied. The actual cautery may be employed to check oozing from cicatricial surfaces, and if it is not allowed to touch the skin, and the wound kept aseptic, no delay in healing need be occasioned. Should the bleeding persist, the wound should be firmly packed.

III. **Secondary Hæmorrhage.**—Under this title are included all forms of hæmorrhage from wounds which occur after the lapse of twenty-four hours. It is almost always due to infection, and was formerly very common, often leading to a fatal termination; since the introduction of antiseptic surgery it is but seldom seen, except where asepsis cannot be fully maintained, as in the mouth, pharynx, etc., or in the treatment of gunshot wounds.

The **Essential Cause** is **infection** of the wound. In a vessel which has been divided and ligatured, as on the face of an amputation stump, the projecting end of the vessel beyond the ligature is practically dead tissue, and therefore readily attacked by bacteria, which transform it into a slough, and this, together with the infected ligature, has to be cast off; when this happens, bleeding may occur. In addition to this, however, the infection of the wound involves a suppurative inflammation around the vessel (periarteritis), which results in a softening of the vascular tunics by the bacterial toxins, and this may progress in time to such an extent as to render them incapable of resisting the blood-pressure, so that, sooner or later, they give way. This latter condition is especially seen in vessels tied in their continuity, and also occurs in the secondary hæmorrhage which sometimes develops in connection with abscesses in the neighbourhood of large vessels, or in deep infected wounds where a drainage-tube or other source of pressure—*e.g.*, the spiculated end of a broken bone—is allowed to rest against an arterial wall (Fig. 95).

Anything which interferes with the vitality of the vessel wall may serve as a **Contributory Cause,** such as its separation from the sheath for too great an extent, thereby cutting off its blood-supply;

or a diseased condition of the arterial wall, as from atheroma; or an unhealthy condition of the patient's blood; or undue elevation of blood-pressure, as in Bright's disease.

After ligature of large vessels, such as the innominate, first part of the subclavian, or common iliac, secondary hæmorrhage may occur apart from infection, if the inner and middle coats have been divided by the ligature. The crumpled-up outer coat exposed just above the ligature by the retraction of the inner and middle coats

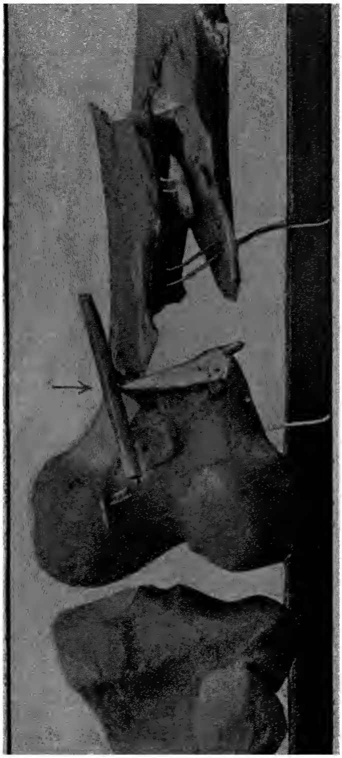


FIG. 95.—PENETRATION OF FEMORAL ARTERY BY SPICULE OF BONE IN COMPOUND COMMINUTED FRACTURE OF FEMUR (GUNSHOT WOUND), CAUSING SECONDARY HÆMORRHAGE

is insufficient to withstand the blood-pressure in such large vessels, and undergoes an aneurismal dilatation, which is certainly followed by hæmorrhage at an early date.

The **Phenomena** are almost always preceded by those of infection of the wound, to which a slight occasional loss of blood is added. This continues with more or less frequency and severity until the patient is either worn out by the constant repetition of small losses, or destroyed by one or two severe gushes from the larger vessels.

The earlier the bleeding occurs, the less serious it is, as it probably comes from the smaller vessels, and can be easily dealt with. When, however, it does not supervene till late, as on the tenth or twelfth day, it usually arises from the larger trunks, and is increasingly severe. When originating from a vessel tied in its continuity, it generally comes from the distal end, since repair is here less effective than on the proximal side of the ligature, and resistance to bacterial infection less vigorous. The explanation of this is that the vasa vasorum reach the artery from the sheath, and run with the blood-current. The separation of the sheath and the application of the ligature necessarily cut off the blood-supply of the vessel wall just distal to the ligature.

Treatment.—The case must be watched night and day until the wound is healthy, as although the bleeding ceases for a while, it may break out again at any time. If the wound is in a limb, a tourniquet should be lightly adjusted above it as a precautionary measure, so that at a moment's notice it may be tightened.

When arising *from an artery completely divided*, as in an amputation stump, elevation of the part after redressing and firm bandaging may be all that is needed in early cases. A recurrence will necessitate the opening up of the wound, and the application of ligatures to the bleeding vessels, if practicable. Sloughs should be cut or scraped away, and the wound packed with gauze soaked in flavine solution and firmly bandaged. If this fails, the artery must be tied just above, or re-amputation performed. When the bleeding comes from the main vessel near the trunk, as after amputation at the shoulder or hip, proximal ligature can alone be depended on, should local treatment be unsuccessful.

When coming *from an artery tied in its continuity*, the wound is opened up, and the artery secured again above and below, whilst every effort is made to combat the infection. Failing this, proximal ligature may be practicable, but for the large vessels of the trunk pressure may be the only resource. Should religature at a higher spot fail or be considered inadvisable, as is often the case in the leg, amputation must be undertaken without delay.

Venous Hæmorrhage.—Bleeding from the smaller veins rarely requires attention, in that the walls, when divided, rapidly collapse, and this checks further loss of blood; but if the larger veins are involved, or if the walls are thickened and rigid, as in varix, a very considerable amount may be lost, the blood welling up in a continuous stream, and rendering its arrest the more difficult from the fact that, except in veins of the largest size, there is no definite jet or gush to guide one to the wounded spot.

Treatment.—Divided veins are usually tied in the same way as arteries, but it is often possible to secure a puncture or tear in a large vein by a lateral ligature without occluding its whole circumference. In amputations it is usual to tie both the main artery and vein. Where it is difficult to reach a vein in order to tie it,

the wound may be packed with gauze over a flap of muscle or fascia applied locally to the wounded vessel.

Secondary Hæmorrhage from veins is not common, but arises occasionally from infection around a large vein, which has been punctured and a lateral ligature applied, or a branch of which has been tied at its point of union with the main trunk. Under aseptic conditions repair of the wounded venous wall is effected without cessation of the circulation in the main trunk. If the wound becomes infected, the ligature is invaded by germs, as also the portion of vein wall within its grasp. In the smaller veins the inflammation induced will result in a protective thrombosis; but in a large vessel, such as the internal jugular, where the blood-stream is rapid, thrombosis may be hindered in its occurrence, and hæmorrhage may result from the wall giving way. The bleeding from cases of this description will usually be severe, but can be easily controlled by pressure or ligature.

The Entrance of Air into Veins is, fortunately, a very rare occurrence, as it is always fraught with grave danger to the patient, inasmuch as it interferes seriously with the circulation, and may even cause death. The air sucked into the veins is carried up to the right side of the heart, and there becomes entangled in the columnæ carneæ, and is churned up into a frothy spumous mixture, which the heart can only eject with difficulty.

The **Cause** is usually a wound of some vein in what is known as the 'dangerous region' of the neck (lower portion) or axilla, or even of such unlikely structures as the pelvic veins or cranial sinuses. During inspiration the movements of the thorax exercise an aspiratory or suction effect upon the blood in the larger veins, and hence any condition which prevents the collapsing of the walls of the veins, or brings about what is termed their *canalization*, predisposes to this accident. Thus they may be held open at spots where they pierce the deep fascia or the platysma; if the coats are thick and rigid from inflammation, or surrounded by indurated tissue, or buttonholed as by excision of a portion of the walls or division of a branch close to the main trunk, or if undue traction is exercised upon the pedicle of a tumour containing a wounded vein, then the orifice may remain patent, and air can be sucked in. If, however, the veins are very distended, as is often the case in the operation of tracheotomy, then a wound, even in the dangerous area, usually results in loss of blood rather than entrance of air.

The chief **sign** is a hissing, gurgling, or sucking sound, which is quite characteristic. A few bubbles of air may also be seen clinging about the aperture in the vessel. If only a small amount has entered, or if the entry is made slowly, no bad results may follow; but the usual effect is to produce severe faintness, and if the patient is conscious, a feeling of dyspnœa and distress. The pulse becomes rapid and almost imperceptible, the pupils widely dilated, and death may follow, preceded perhaps by convulsions. If the patient survives, no after-effects remain.

Treatment.—This accident can usually be avoided by dealing cautiously with all veins in operations about the neck, securing them, if possible, by ligature or forceps before their division. Should it occur, any fresh entrance must be promptly checked by placing a finger over the bleeding-point or pouring lotion into the wound. The wound in the vein should be at once closed. To combat the general symptoms, it is essential to maintain a good supply of blood to the brain. The head is lowered, and, if need be, the limbs raised and bandaged, or the abdominal aorta compressed. Stimulants and artificial respiration are used in order to maintain the heart's action and to overcome the pulmonary obstruction.

Methods of Dealing with Hæmorrhage from Special Sources.

Secondary Branches of the Carotid.—If the divided ends of these vessels, either in the neck or head, *e.g.*, in a cut throat or a punctured wound of the pterygoid region, cannot be secured, ligature of the external carotid between the superior thyroid and lingual should be undertaken rather than tying the common carotid, since the cerebral circulation is not thereby affected.

Vertebral Artery.—Hæmorrhage from this vessel is difficult to recognize, as it is impossible to compress it without also including the carotid; it is feasible, however, to control the carotid apart from the vertebral by pinching it up by the fingers placed on either side of the sterno-mastoid. *Treatment* must follow the usual course of securing the vessel at the bleeding spot, if possible, by ligature or hæmostatic forceps, which are left on for a time. In the upper part of its course the vessel may be exposed by clipping away a transverse process if necessary, due care being taken of the nerve roots. It is most essential that the carotid should not be tied by mistake in these cases, as thereby more blood is directed to the vertebral trunk, and the bleeding is correspondingly increased.

The **Internal Mammary Artery** rarely calls for treatment, since an accidental wound of this vessel is usually complicated with some graver mischief to heart, liver, or lungs. If recognized, tie at the bleeding spot, possibly removing a costal cartilage to gain access. The vessel lies about half an inch outside the border of the sternum.

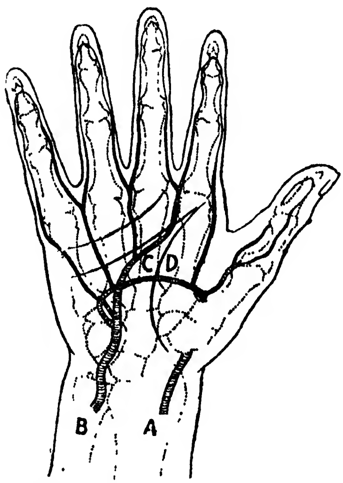


FIG. 96.—HAND, TO SHOW POSITION OF PALMAR ARCHES.

A, Radial artery; B, ulnar artery; C, superficial arch; D, deep arch.

Intercostal Hæmorrhage usually results from penetrating wounds also involving the rib, and is not easily stopped on account of the position of the vessels in the groove.

Treatment.—The overlying piece of rib should be removed so as to expose the bleeding vessel, which can then be isolated and ligatured. Failing this, and if a wound of sufficient size in the intercostal space is present, a piece of aseptic gauze like a pocket is pushed through into the pleural cavity, and packed tightly with wool or strips of gauze; on pulling upon this, firm compression of the vessel may follow with cessation of the bleeding.

Wounds of the **Palmar Arches** were formerly much more dreaded than they are at present, when effective asepsis and the use of the elastic tourniquet allow us to explore the depths of a wound without much danger or difficulty. The position of the wound will usually indicate whether the bleeding comes from the superficial or deep arch, but in case of doubt it is well to remember that pressure on the ulnar trunk mainly affects the superficial arch, whilst pressure on the radial will chiefly influence the deep. A wound of the superficial arch presents little trouble in treatment, as it can be readily secured by catch forceps and ligature; but the deep arch is not so easily dealt with. It lies just over the bases of the metacarpal bones (Fig. 96, D), and to expose it the wound must be freely enlarged by a longitudinal incision, and the tendons turned on one side or separated. It may be possible to secure the vessel by forcipressure forceps, and these may be left on for twenty-four hours if a ligature cannot be applied. Of course, the strictest asepsis is needful in such cases, and passive movement of the fingers must be early undertaken, in

order to prevent troublesome adhesions. Failing such means, or in infected cases, the wound is packed with sterilized gauze, and over this the fingers are firmly bandaged. The patient is kept in bed for a few days, and the arm elevated. Pressure on the main vessels above is scarcely necessary if the compress is accurately applied. The bandages may be relaxed at the end of twenty-four hours, but the deep dressing should, if possible, not be touched for three or four days. If, in spite of this, bleeding recurs, the main vessel or vessels of the limb must be tied. Ligature of the ulnar and radial arteries at the wrist is generally insufficient to control it, as there is often a communicating branch of some size passing from the anterior interosseous to the deep arch, and hence it may be needful to secure the brachial artery, ascertaining first, however, by pressure that this will be efficacious; for occasionally there is a high division of the brachial, or a vas aberrans may exist, which would compel the surgeon to tie the third part of the axillary.

Bleeding from the **Plantar Arch** must be conducted on similar lines.

The **Gluteal, Sciatic,** or **Pudic** arteries may be wounded by stabs in the buttock. *Treatment.*—Enlarge the wound in the direction of the fibres of the gluteus maximus, *i e* , downwards and outwards, and secure the bleeding vessel. The gluteal trunk emerges from the pelvis at the junction of the middle and inner thirds of a line from the posterior superior iliac spine to the great trochanter (Fig. 97, G); the pudic crosses the ischial spine at the junction of the middle and lower thirds of a line from the posterior superior iliac spine to the tuber ischii (S). The sciatic emerges from the pelvis just above and a little external to the latter spot. The pudic may also be divided in the perineum by a penetrating wound. Failing ligature of any of these arteries at the seat of bleeding, the internal iliac should be secured.

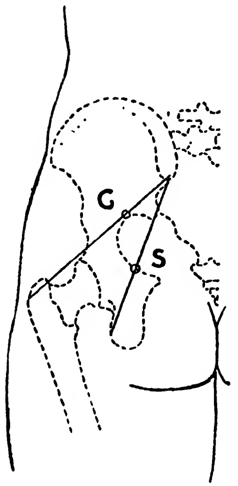


FIG. 97.—DIAGRAM OF PELVIS TO INDICATE SITES OF EMERGENCE OF G, THE GLUTEAL ARTERY, AND OF S, THE SCIATIC AND PUDIC ARTERIES.

Hæmophilia.

By hæmophilia, or the hæmorrhagic diathesis, is meant a disease, either congenital and hereditary, or casual and accidental, characterized by a tendency to persistent and uncontrollable bleeding from slight wounds, whether open or subcutaneous. This condition is often associated with extravasation of blood into the joints and certain consecutive phenomena (Chapter XXIII.). The family history of the hereditary cases is interesting, the disease being usually transmitted through the females of one or more generations to the males, whilst the former may escape entirely. Unless hæmorrhage is actually occurring, nothing abnormal is noticed, but any injury is sure to be followed by excessive bleeding; spontaneous subcutaneous ecchymoses frequently occur, as also bleeding from the mucous membranes. Hence no operations must be undertaken on such patients unless absolutely urgent, even such a small matter as the extraction of a tooth having proved fatal.

When blood escapes from a damaged vessel into the tissues, or from a wound on a free surface, the extravasated blood gradually coagulates or clots, due to formation of a meshwork of fibrin. This clotting is a protective mechanism, which safeguards the body against excessive loss of blood. The fibrin is formed by the action of thrombin on fibrinogen. Fibrinogen is a normal protein constituent of blood-plasma, while thrombin is formed by the action of the thrombokinase on prothrombin in the presence of free calcium ions. When the blood

escapes from the vessels it is acted on by thrombokinase present in the tissue fluids, or formed from the damaged endothelium of the vessels, and also from the blood-platelets and leucocytes. With blood from normal persons, the time taken for shed blood to clot is practically constant under constant conditions. Using Dale and Laidlaw's method, in which the blood is allowed to flow into a capillary tube containing a lead shot, and maintained at 37° C., the time taken by the blood to clot sufficiently firmly to arrest the lead shot is 1¾ minutes. This clotting time is prolonged in some cases of purpura, but the prolongation is especially marked in hæmophiliacs. The delay in hæmophilia appears to be due to a deficiency of thrombokinase, especially in the blood-platelets. The platelets are normal in numbers, but are defective in quality. The addition of normal platelets to hæmophilic blood causes normal clotting, and it has been shown that there is no deficiency either in the calcium or fibrogen in this disease.

Treatment must be directed mainly towards the artificial provision of those substances which are defective in the blood. Whole blood transfusion is undoubtedly the best procedure, but there is now available a serum of hæmostatic value, known commercially as Hæmoplastin, which contains prothrombin and other bodies required for determining coagulation; 2 to 4 c.c. of this serum, diluted perhaps with normal saline solution, are injected under the skin, or for choice into a vein. Horse or ox serum given by mouth or subcutaneously may also be of some use. Locally, pressure and cold are mainly relied on, but adrenalin, hæmoplastin, or cocaine may be applied on gauze to the bleeding spot.

CHAPTER XIII.

INJURIES AND DISEASES OF ARTERIES—ANEURISM—LIGATURE OF ARTERIES.

Injuries of Arteries.

Contusion of an artery is the result of violence applied directly to the vessel wall. If atheroma or calcification exists, thrombosis often follows slight injuries, and dry or senile gangrene may ensue; but in healthy arteries a good deal of violence is needed to produce such an effect, as their natural elasticity enables them to yield or slip aside, and thus the consequences are usually insignificant.

Rupture or **Laceration** may also follow blows or strains, or may result from fractures or dislocations, or from attempts to reduce old-standing dislocations, or to break down intra-articular adhesions. If the rupture is **partial,** the inner and middle coats are usually torn, and this may be followed by thrombosis and occlusion. Where the lesion is limited to one side of the vessel, the clot may become organized over that spot, narrowing the lumen, but leaving an area of weakness from which an aneurism may subsequently develop. A dissecting aneurism (p. 353) may also result from such an accident. When complicated with a suppurating wound, an infective periarteritis may ensue, giving rise later on to secondary hæmorrhage.

Complete Rupture of an artery in a severe lacerated wound, such as is produced when a limb is torn off, often leads to but little hæmorrhage; the inner and middle coats give way at a higher level than the adventitia, and curl up within it, whilst the outer coat and sheath contract over them, and form an effective barrier. If, however, the artery is ruptured in a subcutaneous injury, such as a fracture or dislocation, extensive interstitial extravasation often ensues. A similar condition may ensue from a punctured wound of a vessel, where the track leading to it is valvular or becomes closed by clot or some external application.

The blood escapes into the tissues which are pushed aside and displaced, so that in time a cavity is formed, filled with fluid blood or soft clot, and surrounded by the tissues of the part, which after a time become matted together to form a fibrous wall lined by a deposit of fibrin of varying thickness. The size and shape of the cavity are determined by the resistance of the surrounding structures; thus in the upper part of the axilla the clavicle, costo-coracoid

membrane, and pectoralis minor prevent extension forwards, and the tumour occasioned by the extravasation presents itself in the axilla or above the clavicle. As a rule the swelling develops rapidly, but sometimes hæmorrhage is prevented by temporary blocking of the opening in the artery, and may only be lighted up later by injudicious movements or violence.

Symptoms.—The patient usually complains of feeling a snap, as though something had given way, accompanied by a sudden pain, localized to the injured part and often shooting down the limb in the line of the vessel. These are succeeded by the following phenomena: (*a*) *Locally*, a diffuse rapidly increasing swelling forms, which may be well described as a *Pulsating Hæmatoma ;* this is tense and firm to the touch, and as the amount of fibrin increases may feel distinctly hard. It is not as a rule reducible, and indeed manipulation to determine this point is injudicious, as it may dislodge a portion of clot. Distinct pulsation of an expansile type is usually present, and often a systolic bruit and some degree of thrill, but these may not develop if the cavity is very tense, or if much fibrin is present, or if the wounded artery is very deep. The skin is stretched, but remains unchanged unless the swelling is approaching the surface. (*b*) *Distally*, the signs depend on the amount of interference with the circulation and with surrounding structures, especially the nerves. If the artery is torn completely across, the pulse in the vessels below ceases, and œdema may result from pressure of the blood-clot on the veins; if the artery is only partially divided, some amount of circulation distally may persist. Pressure on the nerves at first causes numbness, tingling and neuralgic pain, but later on may determine loss of power or complete anæsthesia. It must not be forgotten, however, that some of the nerves adjacent to the injured vessel may have been wounded simultaneously with the artery. (*c*) *Generally*, the signs of hæmorrhage and shock manifest themselves in varying degree, according to the amount of blood lost and the character of the violence.

Results.—(1) The swelling may increase steadily in size until the skin becomes so distended as to *rupture* or slough, and then, if help is not at hand, the patient dies of hæmorrhage. Occasionally the bleeding continues into an internal cavity, or into the tissues of a limb, to such an extent as to cause death without any external loss of blood. (2) *Suppuration*, accompanied by the general signs of fever, may result from auto-infection, or from the entrance of bacteria through the small valve-like wound. The whole swelling becomes red, hot, œdematous, and excessively tender, looking like a large abscess. Rupture and external hæmorrhage will probably conclude the case if surgical assistance cannot be obtained. (3) The pressure of the extravasated blood upon the veins or on the arteries needed for the collateral circulation may determine *gangrene* of the extremity, which is almost always of the moist type. (4) The process may become more or less *limited* after a time by coagulation occurring in the divided mouth of the vessel, which is thus occluded. Collateral

circulation may be established, and thereby the health and vitality of the limb are maintained, whilst the blood-clot is absorbed or organized.

Treatment.—Whenever practicable, the part should be laid open, the clots turned out, and the injury to the arterial wall repaired. To undertake this, temporary hæmostasis must be secured by the use of a tourniquet in a limb, or by digital compression, or by applying a temporary ligature or a Crile's clamp to the trunk above. In some cases—*e.g.*, a torn artery in the buttock—none of these plans are feasible, and then it may only be possible to make an opening in the sac just large enough to introduce a finger, and with this the actual bleeding-point must be sought and controlled, and then the wound can be laid freely open and the vessel secured. In some cases it will be necessary to release the tourniquet or clamp for a moment or two in order to find the upper end, but as a rule this is not a difficult task. The lower end is often more difficult to find, though if it can be exposed at a lower level it may be possible to trace it up; if, however, this is unsuccessful, owing to the infiltrated condition of the parts, then the cavity, after being emptied of clot, is well packed with gauze, and a tourniquet kept on the limb for immediate use, if need be. It is most important to ligate or deal with the actual wounded end of the vessel; proximal ligature may be quite ineffective, owing to the existence of a branch between the ligature and the wound.

If gangrene is threatening or secondary hæmorrhage occurs, amputation is usually the only resource.

In the later stages where the arterial hæmatoma is becoming limited, and a considerable deposit of fibrin is present, proximal ligature of the main trunk is sometimes most successful in determining a cure.

A **Penetrating Wound** of an artery, if completely dividing the vessel, is always followed by hæmorrhage, although the blood may be unable to escape externally. If a large artery is cut cleanly across, the bleeding is copious, whilst from a small vessel it soon ceases, owing to the contraction and retraction of the coats.

When an artery is 'buttonholed'—*i.e.*, when a small segment of the wall is cut through—the hæmorrhage is often continuous and prolonged, since retraction opens up the wound, and contraction is thereby hindered. The treatment of this condition consists in completing the division of the injured trunk if it is a small one, but if it is of large size, it must be dealt with according to the rules given below for punctured arteries.

If an artery is divided close to its origin from the main trunk, the blood escapes with a jet, the strength of which is proportional to the blood-pressure in the latter, and the treatment must be as for a buttonholed artery.

A clean incised wound of an artery varies in its results somewhat according to its direction; thus if it is in the long axis of the vessel, it gapes but little, and the loss of blood may be but slight, whilst

if transverse or oblique, both contraction and retraction tend to increase the size of the opening, rendering it more nearly circular, increasing thereby the hæmorrhage.

A punctured wound of an artery varies in its results with the size and character of the penetrating body. Thus a vessel may be traversed by a needle without hæmorrhage, or subsequent ill-effect, but a larger puncture, as by the blade of a knife or stiletto, results in extravasation. If it ceases after a time, the blood-clot is absorbed and the wound in the vessel closed by a cicatrix, which may subsequently yield and give rise to a circumscribed aneurism. This is not unfrequent in the neighbourhood of the wrist from glass wounds, involving the radial or ulnar trunks, and hence is usually seen in window-cleaners or mineral-water bottlers.

Somewhat similar results follow from the passage of the small conical bullets employed in modern warfare; it is quite possible for a large artery to be traversed by such a projectile and very little harm to follow. Shell fragments usually cause wounds of a more ragged type, but they too may be of small dimensions. It is sometimes possible for both walls of the vessel to be penetrated and for aneurismal developments to occur on each side of the main trunk without communication with each other; possibly an aneurism of the traumatic type develops on one side, and an arterio-venous lesion on the other.

Treatment.—So much progress has been made of recent years in connection with the surgery of arteries that it is now accurate to say that the ideal treatment of all penetrating lesions of arterial walls is the repair of the lesion and restoration of the lumen of the vessel; of course, this dictum applies only when the arterial tunics are healthy; when they are in a pathological condition repair is rarely possible, and then all that can be done is to apply ligatures above and below the wound in the vessel, as also to any branch that may arise between the ligatures. Simple linear wounds or slits in the arterial wall may certainly be sutured with every prospect of success if certain precautions are taken. The circulation must first be controlled, and the most stringent precautions taken as to asepsis. The hæmatoma is opened up by a suitable incision, and all the blood-clot turned out so as to expose the wound in the vessel. The lesion is carefully but thoroughly explored to ascertain whether it involves only one or both sides of the vessel, and then sutures are introduced passing through all the coats of the artery down to, but not through, the intima. Fine silk is employed, previously sterilized in vaseline or in liquid paraffin at 105° C.; the needle should be round-bodied, of the smallest size, and straight or curved, as may be thought best. If the wound in the vessel is irregular, and yet appears to be capable of *lateral suture*, the irregular margins should be carefully trimmed, clots removed, and the parts lightly rubbed over with sterile paraffin; the lumen of the artery may be slightly encroached on, but that is better than ligation of the vessel, or an end-to-end anastomosis.

For irregular tears of an artery or when the whole calibre has been

involved, and possibly some retraction has taken place, ligature is often the only practicable method of treatment, but in experienced hands and when the conditions are favourable, it may be possible to excise the injured area, to free the vessel above and below, guarding carefully all branches, and then to restore the vessel by an *end-to-end anastomosis*. An inch or more of a main trunk may be removed, and yet a successful issue follow if tension on the anastomosis is avoided by suitable position of the limb. Larger textbooks must be consulted for details as to operative technique.

Arterio-Venous Wounds follow penetrating injuries which involve an artery and vein lying in close contact—*e.g.*, at the bend of the elbow between the median basilic vein and the brachial artery, in the neck between the internal jugular and carotid, in the leg between the femoral vessels, and occasionally in the orbit. They are also not unfrequently met with in military surgery, as a result of the penetration of tiny shell or bomb fragments, or even of a bullet which does but little harm to the soft tissues. Small vessels may be involved as well as the main trunks—*e.g.* (to mention a few actual cases), the facial artery and the temporo-facial vein, the transverse cervical artery and vein, one of the smaller arteries of the groin and the upper end of the internal saphena vein, etc. Two conditions may result.

An **Aneurismal Varix** is produced by a direct communication between an artery and a vein, no dilated passage intervening between the vessels (Fig. 98, A). The venous walls, unfitted to withstand arterial pressure, are thereby dilated and rendered varicose. A pulsating venous tumour results, the dilatation extending for a variable distance above and below the opening, and at each beat of the heart a loud whizzing sound can be heard, likened by some authors to that caused by an imprisoned bluebottle buzzing in a thin paper bag. On palpation the thrill of the blood as it enters the vein can often be detected.

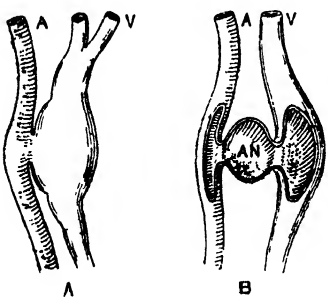


FIG. 98.—DIAGRAM OF *A*, ANEURISMAL VARIX, AND *B*, VARICOSE ANEURISM.

A, Artery; V, vein; AN, aneurism.

Treatment.—Nothing is usually required beyond the application of an elastic bandage or support to prevent further enlargement. Should pain or inconvenience arise in spite of this, it may be possible to repair the wound in the arterial wall by suture, or, failing that, the artery must be secured above and below the abnormal communication with the vein. Generally the latter is so distended that it has to be removed before the artery can be reached, but the

simultaneous occlusion of artery and vein is not a very serious matter in these cases (p. 125).

A **Varicose Aneurism** differs from the above in that an aneurismal sac exists between the artery and the dilated vein (Fig. 98, B). It is produced when the vessels are placed at a short distance from each other, or when extravasation of blood has separated them. The aneurism is of the false type, its walls being composed of newly-formed cicatricial tissue; it is almost certain to become diffuse. The physical signs are similar to those of aneurismal varix, except that the aneurism can sometimes be detected by palpation, whilst a soft bruit may be heard over it.

Surgical **Treatment** is always required in these cases. An attempt should be made to repair the damage to the walls of the artery and vein, either by lateral suture or by end-to-end anastomosis. Not unfrequently this type of treatment is impracticable, and then the damaged sections of the vessels together with the aneurism may be excised with good results, since the lesion usually occurs in healthy adults. It may suffice, however, to tie the artery immediately above and below the wound.

Inflammation and Degeneration of Arteries.

1. **Traumatic Arteritis** is the result of injuries, such as total or partial division of the vessel, laceration, bruising, etc. The phenomena are merely those of repair, resulting in closure of the wound or occlusion of the vessel; they have been already described.

2. **Infective Arteritis** results from bacterial invasion of the arterial wall, and that usually from without (*periarteritis*) and in connection with infected wounds and ligatures, or spreading ulceration. It is characterized by hyperæmia and softening of the vascular tunics, the fibres of which lose their cohesion with each other, owing to the peptonizing action of the toxins. In the smaller arteries thrombosis usually occurs and seals the vessel; but in the larger there is considerable danger of bleeding. Secondary hæmorrhage from arteries tied in their continuity is generally due to this cause, as also bleeding from phthisical cavities, the vessels having previously lost the support of surrounding tissues, and being more or less dilated or aneurismal.

3. **Embolic Arteritis.**—When a vessel is blocked by a simple embolus, obliteration is the usual consequence. If the embolus is infective, as in pyæmia or infective endocarditis, an abscess may develop; but if the irritant is less intense, the process may stop short of suppuration, and yet an aneurismal dilatation of the softened wall takes place. The latter process is the most common cause of *spontaneous* aneurism in children and young adults.

4. **Acute Endarteritis** is usually seen in the aorta associated with acute endocarditis, or sometimes in the smaller vessels near inflamed wounds. It is evidenced by the presence on the inner aspect

of the vessel of more or less raised patches, somewhat pinkish and gelatinous in appearance, soft and elastic in consistency.

5. **Arterio-sclerosis** is the term now applied to a degenerative and inflammatory affection of the arteries, formerly known as *chronic endarteritis*. It usually commences about middle life, and is in many cases merely a physiological sign of the incidence of senility due to the wear and tear of life. In younger patients and in its more severe forms it generally depends on some form of chronic intoxication—*e.g.*, syphilis, gout, alcoholism, or lead-poisoning. It is also induced by excessive and particularly intermittent muscular strain; by cachexia, the result of malignant disease, tuberculosis, or inanition; it may follow as a sequela of acute infections, such as

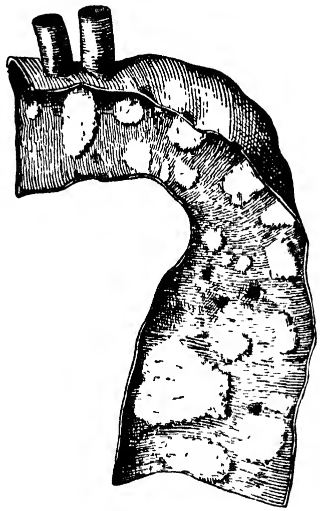


FIG. 99.—ATHEROMA OF AORTA.

enteric fever or acute rheumatism; or may arise from any condition which leads to persistent increase in the arterial tension—*e.g.*, chronic Bright's disease.

The primary changes probably consist in a degenerative loss of elasticity in the middle and outer coats, which is followed by a secondary hyperplasia of the tunica intima. The later effects vary somewhat, according to whether the affection is localized (nodular variety) or diffuse.

Nodular Arterio-sclerosis or *atheroma* is most common in the aorta and large vessels, and often starts in the convexity of the aortic arch at the spot where the impact of the blood-stream is felt as it is ejected from the ventricles (Fig. 99), or in places where the vessel passes over or around some bony projection, or at the bifurcation of a main artery. In the early stages scattered raised patches are

seen on the inner lining of the vessel, translucent and grayish in aspect, and of variable size; the overlying endothelium is smooth and intact. In the later stages fibrosis may occur in the patch, which becomes dull white in colour, and at length calcification may ensue, giving rise to an atheromatous plate. In other cases the process may be followed by fatty degeneration, the patches becoming yellowish in colour and irregular in outline; they are small at first, but increase in size, and coalesce one with another. The contents are now fluid or cheesy in consistency, the pultaceous material consisting of fatty granules and débris, with oil globules and plates of cholesterine (Fig. 100, f^1). It may be absorbed entirely, leaving a

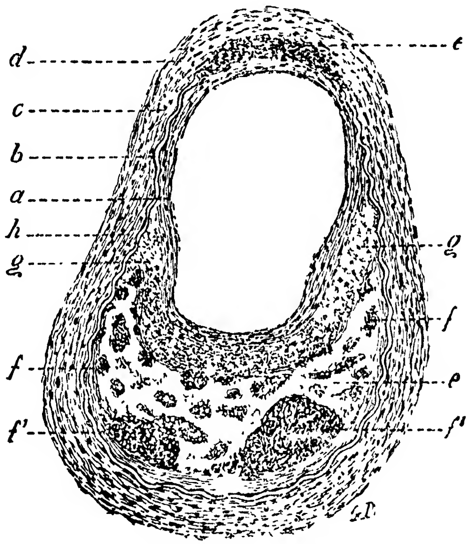


FIG. 100.—SECTION OF ATHEROMATOUS CEREBRAL ARTERY. (×50.) (ZIEGLER.)

a, Intima considerably thickened; *b*, bounding elastic lamella of intima; *c*, media, *d*, adventitia; *e*, necrosed denucleated tissue with masses of fatty detritus; *f* and f^1, detritus with cholesterine tablets; *g*, intima infiltrated with leucocytes; *h*, infiltration of adventitia with leucocytes.

weakened spot in the wall of the vessel, from which an aneurism may arise; or it may be infiltrated with lime salts, and constitute an atheromatous plate; or the tunica intima may give way over it, allowing the contents to be swept into the general circulation, where it probably does no harm. The outer coat has by this time become thickened, and hence no immediate ill result follows the breach in the inner coats, although subsequently dilatation may take place. Again, the blood may find its way through the opening into the substance of the wall and strip up the inner from the outer layers, constituting a 'dissecting aneurism'; or a localized thrombus may form, causing occlusion of the vessel.

Diffuse Arterio-sclerosis occurs in elderly individuals, commonly in the smaller vessels, and may be associated with the nodular variety in the aorta. The changes are similar to those described above, but usually terminate in fibrosis and contraction of the lumen of the vessel; the changes in the intima are followed by thickening of all the coats, but degenerative phenomena are unusual. In the smaller arteries of the brain this change may interfere seriously with the functions of the part; whilst in the vessels of the limbs it may result in what is known as *Endarteritis obliterans*, and lead to gangrene. In some instances even the main trunks may be involved in this affection.

6 **Chronic Syphilitic Endarteritis** is chiefly met with in the late secondary or tertiary stages, and is characterized by an overgrowth

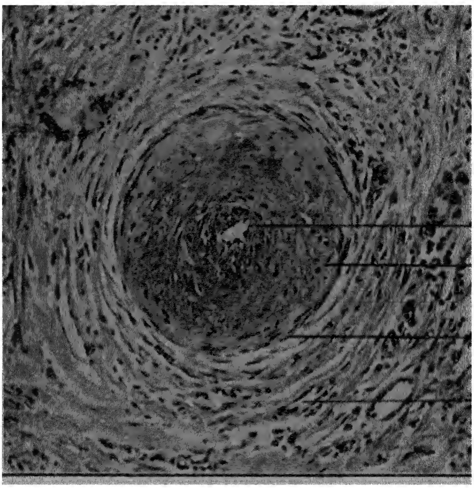


FIG 101 —SYPHILITIC ENDARTERITIS FROM NEAR A GUMMA. (× 120.)

a, Intima greatly thickened by newly-formed fibro-cellular tissue, *b*, fenestrated elastic lamina of Henle; *c*, muscle fibres of media infiltrated towards the left, *d*, adventitia thickened by cell infiltration and hyperplasia.

of the tunica intima (Fig. 101, *a*), which is subsequently associated with infiltration of the media (*c*), and much more so of the adventitia (*d*). The change occurs in small arteries, especially those of the brain or kidneys, or in the neighbourhood of gummata, and but rarely in the larger vessels, although a considerable percentage of individuals affected with internal aneurism have suffered from syphilis. It differs from simple atheroma—(1) in attacking small arteries; (2) in affecting the whole circumference of the vessel, and not merely patches; (3) the newly-formed tissue becomes vascular, and does not undergo fatty degeneration; and (4) it leads to narrowing or occlusion of the vessel rather than to weakening and dilatation When involving the cerebral arteries, various forms of monoplegia, or even hemiplegia, may result

7. **Chronic Tuberculous Endarteritis** of a similar type is met with in all places where tubercle is actively developing; in fact, tubercles are often formed around arterioles, and lead to their obliteration. The tuberculous endarteritis may, however, spread widely beyond the focus of the mischief, and in almost any portion of pulpy granulation tissue this change can be seen.

8. **Primary Calcareous Degeneration** (Fig. 102) is chiefly met with in the smaller arteries of the extremities. It occurs in elderly people at the same time of life as the calcification of cartilages, etc., and commences by the deposit of lime salts in the muscular fibres of the tunica media, constituting a series of calcareous rings which trans-

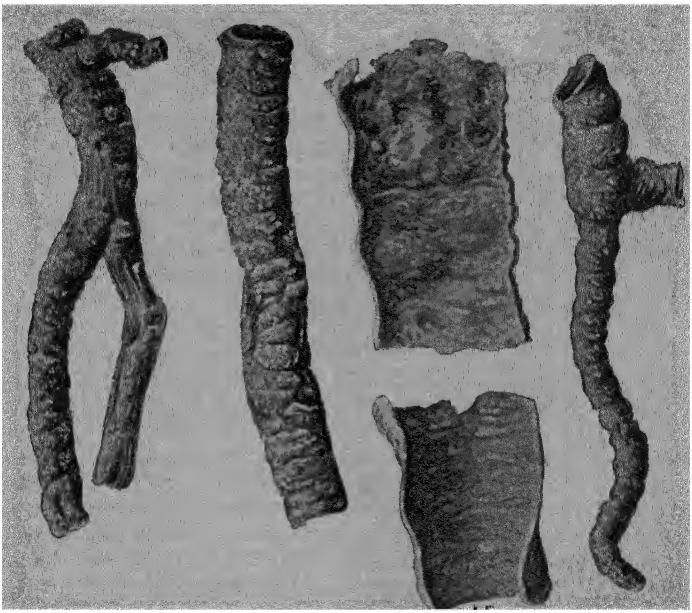


FIG. 102.—PRIMARY CALCAREOUS DEGENERATION OF ARTERIES. (FROM COLLEGE OF SURGEONS' MUSEUM.)

form the elastic expansile vessels into rigid tubes like gas-pipes, through which can pass only a fixed minimal supply of blood. It is often associated with generalized arterio-sclerosis. The condition is often revealed by radiography

The affected limb passes into a condition of chronic anæmia and impaired nutrition, resulting in coldness of the feet or hands, cramps and spasms of muscles, sensations of pins and needles, etc. The endothelium is not removed except in the later stages, and then thrombosis may be produced, or a similar result may arise from the lodgment of an embolus. Senile gangrene (p. 119) is a common termination. X

9. **Amyloid Degeneration** of the viscera commences in the arterial walls, but is described elsewhere (p. 75).

The Effects of Arterial Inflammation and Degeneration are both local and peripheral. *Locally*, **Thrombosis** may be produced whenever the lining endothelium is removed and a raw surface exposed, upon which fibrin can collect. Under this fibrinous coating repair is often effected without further complication: but if the blood-stream is retarded, or the lumen of the tube narrowed, complete thrombosis may follow, the clot extending some distance up or down the vessel, or even from a branch into the main trunk, which may be blocked by this means. **Aneurism** is also a result of any weakening of the arterial tunics. **Obliteration** of the artery is caused, either by thrombosis, or by excessive proliferation of the tunica intima (as in syphilitic or tuberculous disease), or by gradually increasing pressure from without. Lastly, **Spontaneous Rupture** is occasionally produced.

Peripherally, defective blood-supply and consequent **lowered vitality** are the most marked results of arterial disease, leading to various forms of ulceration and gangrene. Thus, senile gangrene is due to calcareous changes in the arteries, fatty degeneration of the heart follows atheroma of the coronary arteries, whilst softening of the brain may ensue from various affections of the cerebral vessels. Similar results may also arise from **emboli** detached from areas of local disease.

Aneurism.

An **Aneurism** is a sac filled with fluid or coagulated blood communicating with the interior of an artery, the walls of which have become dilated.

Causes.—1. **Changes in the Vessel Walls**, by which their resistance to the intravascular pressure is diminished. Many varieties of *disease, e.g.*, atheroma, predispose to aneurismal dilatation, especially if occurring in syphilitic or gouty men about middle life, in whom, although the arterial tunics may be weakened, the power of the heart and the resulting blood-pressure are by no means diminished. The diffuse form of arterio-sclerosis (often associated with calcification) of the peripheral arteries is antagonistic to aneurismal dilatation. Any *injury*, a contusion, a penetrating wound, or a strain, may so interfere with the integrity of the vascular coats as to result in aneurism and, indeed, a cicatrix in an arterial wall must always be looked on as a weak spot predisposing to dilatation. The lodgment of an infected *embolus* in the smaller arteries is stated to be one of the most common causes of spontaneous aneurism in young people.

2. **Increase in the Blood-Pressure** is another factor, especially when due to heavy *strain* or *exertion*, which leads to irregular excitement and increased action of the heart. Steady laborious employment, such as is seen amongst artisans and mechanics, or regular exercise, does not appear to predispose to this condition; but irregular intermittent efforts, in which for the time being every

ɔwer is strained to its utmost, are very liable to determine its :currence. A day's exertion in the hunting or shooting field by ı elderly man, accustomed to sedentary occupations, is often ıe cause of some vascular lesion, such as aneurism, apoplexy, :c. Hence aneurisms are more frequently seen amongst men ıan in women, in the proportion of seven to one; whilst they re much more common among the dwellers in Northern climates han in the more lethargic and ease-loving inhabitants of the outh.

Structure of an Aneurism.—The *sac* consists more or less evidently f a distension of all or part of the original walls of the vessel whilst t is small; but as the aneurism ncreases, the original structure s replaced by a mass of newly-formed fibrous tissue, due to a condensation and matting together of the surrounding structures, with or without an internal lining of laminated fibrin deposited on parts where the endothelium has disappeared. The *contents* of the sac depend on the character, age and size of the aneurism. Whilst still small and with a complete endothelial lining, it contains fluid blood; but as the tumour grows, and especially if of the sacculated type, fibrin is deposited in layers which gradually encroach on the cavity, and may in time completely fill it, so that in rare cases a spontaneous cure results. The oldest laminæ are dry and yellowish-white in colour; those more recently deposited are softer and more reddish, whilst the last formed is merely like ordinary blood coagulum. No single lamina covers the whole area, but layer is arranged over layer (Fig. 103) in such a manner that the oldest and necessarily the smallest laminæ are nearest to the sac wall.

FIG 103 —SACCULATED ANEURISM (MUSEUM OF ROYAL COLLEGE OF SURGEONS)

The small mouth of the saccule is clearly seen, and the cavity is nearly filled with laminated clot.

Three chief **forms** of aneurism have been described: the fusiform, sacculated, and dissecting.

1. The **Fusiform Aneurism** (Fig. 104, A) is one in which the whole lumen of the vessel is more or less equally expanded, so that the swelling is tubular in character. It is generally due to a widely-

extended disease of the arterial walls, and hence is more common in the larger internal vessels, such as the aorta, than in those of the extremities. The tunica intima is usually represented throughout the whole extent of the sac, but is thickened and atheromatous in patches, the margins and surfaces of calcareous plates being indicated by flocculi of fibrin, which are attached to them, although no regular laminated deposit may be present. The tunica media is stretched, atrophied, and in the later stages practically non-existent, whilst the adventitia is much thickened by inflammatory new formation and by incorporation with the surrounding tissues. The progress of fusiform aneurisms is generally slow, so that in some situations, *e.g.*, the thorax, they may attain enormous dimensions, and cause grave pressure symptoms. A natural cure is almost

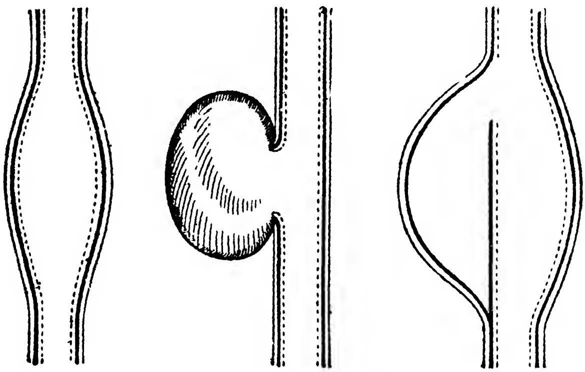


FIG 104.—DIAGRAMS OF FUSIFORM, SACCULATED, AND DISSECTING ANEURISMS.

In the fusiform (A) the walls are expanded, but more or less normal in texture; in the sacculated (B) the normal structure of the arterial wall ceases abruptly at the commencement of the saccule; in the dissecting (C) the arterial wall is split into two lamellæ.
The interrupted fine line is supposed to represent the intima; the continuous dark line, the media; and the continuous fine line, the adventitia.

impossible, and hence, if unchecked by treatment, rupture of the sac is likely to occur, especially if, as often happens, one portion of the wall yields more rapidly than another, thereby inducing a localized sacculation.

2. **A Sacculated Aneurism** (Figs. 103 and 104, B) is due to the yielding of some weak patch in the vessel wall which does not involve the whole circumference, or, as just mentioned, it may spring from a fusiform aneurism. It communicates with the interior of the artery by an opening of variable size. All traumatic aneurisms, whether due to the yielding of a cicatrix, or to the partial division of the coats of the vessel, are of this type, which is hence found most commonly in the extremities. The inner and middle coats can usually be traced

as far as the mouth o the saccule, but there they are suddenly lost, the wall being constituted by a mass of fibro-cicatricial tissue, upon which laminated fibrin readily forms, thus increasing its thickness and power of resistance. Their progress is, however, much more rapid than that of the fusiform, generally ending in rupture or diffusion, although occasionally a natural cure results.

3. A **Dissecting Aneurism** (Fig. 104, C) is one in which the blood forms a cavity within the wall of the vessel by stripping up the inner from the outer half, the line of cleavage being within the middle coat, half going with the adventitia, half with the intima. It is usually the result of extensively diffused atheroma. The blood thus driven into a cul-de-sac may remain limited to this cavity for some time, or it may find its way outwards and become diffused, or burst back through another atheromatous spot in the interior of the vessel. The condition occurs chiefly in the thoracic or abdominal aorta, but cannot be recognised *ante-mortem*.

Symptoms and Signs of a Circumscribed Aneurism.—These may be divided into two groups: the intrinsic and extrinsic.

Intrinsic Signs.—A tumour, pulsating synchronously with the heart's beat, is present in the course of a vessel. The pulsations are distensile or expansile in character, *i.e.*, the whole tumour increases in size at each systole, and that evenly in all directions, so that if the tumour is lightly grasped in any position the fingers are separated. A definite thrill can often be felt as the blood enters the sac at each heart-beat. If the supplying vessel is compressed on the proximal side, the pulsation ceases, and the tumour diminishes in size and becomes softer; this is more marked in fusiform than in sacculated aneurisms. The application of pressure to the sac itself, whilst the afferent trunk is compressed above, may still further diminish its size. On removing the pressure, the swelling regains its old dimensions in a certain definite number of beats, usually not more than two or three. Pressure on the distal side of the sac makes it more tense and the pulsation more marked, unless such compression is very prolonged. On auscultating the tumour, a bruit of variable character may be heard; usually it is loud, harsh, and systolic, but sometimes quiet and musical. It is occasionally double in some forms of sacculated aneurism, and in the aorta when regurgitation through the aortic valves is also present. The bruit is loudest and most rasping in the fusiform variety, and may be absent in the sacculated form, when the mouth is small and the cavity nearly full of clot.

The **Extrinsic Signs** of aneurism are those occurring in neighbouring or distal structures from its constantly increasing size and **pressure**, and the interference produced by it with the circulation. The *pulse* on the distal side is diminished and delayed, its diminution being caused partly by the obstruction experienced, but also in some cases by the pressure of the sac upon the trunk above or below the tumour. The delay is due to the interference with the transmission of the heart's impulse by the intervention of the aneurismal sac.

The smaller vessels engaged in establishing collateral circulation may be compressed by the sac, and thus the vitality of the limb impaired Pressure on the accompanying vein or *veins* results in diminution of their calibre, and possibly a localized thrombosis, together with distal congestion and œdema. Compression of *nerves* occasions neuralgia, spasm, or paralysis. *Muscles* are displaced, expanded, and attenuated; *bones* may be eroded, as evidenced by a deep, constant, boring pain, and even spontaneous fracture may ensue; whilst *joints* are encroached upon and disorganized. *Tubes*, such as the trachea or œsophagus, are often constricted and even laid open by ulceration. It is interesting to note that resisting tissues, like bone, are much more liable to be eroded than elastic, yielding structures, such as cartilage; where the vertebral column is encroached upon by an aneurism, the bones are always destroyed more than the intervertebral discs.

A certain amount of compensatory hypertrophy of the *heart* is often present. Fibrinous masses are occasionally set free as *emboli*, and lead either to a spontaneous cure, or to gangrene of the parts supplied by the vessel, or to death if the brain is involved. *Gangrene* may also result from the diminished blood-supply to peripheral parts; it is usually of the dry type, involving merely one or two fingers or toes, unless the veins are compressed, when it may be of the moist variety.

The **Differential Diagnosis** of a circumscribed aneurism is usually not difficult, but the following conditions may simulate it somewhat closely: 1. A *tumour* or *chronic abscess* situated near an artery, and deriving *transmitted pulsation* from it, is recognised by the impulse being merely heaving in character, and not expansile; by the pulsation ceasing entirely if the tumour is lifted from the vessel, or allowed to fall away from it by assuming a suitable position; by the size of the tumour not diminishing if the pulsation is stopped by pressure on the vessel above; and by the fact that after stoppage of the pulsation the first beat is equal to the subsequent ones, whereas in an aneurism it almost always requires more than one beat to re-establish the strength and force of the impulse. Moreover, the pulse below is not affected in the same way or to the same extent as when an aneurism is present. 2. An *artery* is sometimes *pushed forwards* by an underlying growth, and its pulsation in a more than usually superficial position may suggest an aneurism. The distinguishing features are the limitation of the pulsation to the line of the vessel, and the absence of pulsation in the underlying growth. 3. A *pulsating sarcoma* or *nævus* is known by being rarely limited exactly to the line of the artery, pulsation being present in situations where an aneurismal dilatation could not be felt, and being less forcible and regular in its character. The consistency of the swelling is more variable, and pressure over the afferent trunk does not diminish its size to any marked extent. Moreover, a sarcoma is usually more adherent to the deeper structures, and its limits are not so accurately defined. 4. The pain caused by an aneurism may lead it to

be mistaken for *rheumatism or neuralgia* (*e.g.*, for sciatica in popliteal aneurism). and in every case of obstinate pain of this kind the arteries should always be carefully examined.

Natural Terminations and Results.—1. **Spontaneous Cure,** though very unusual may occur in sacculated aneurisms. (*a*) It may be due to the *gradual* deposit within the sac of fibrin, which, in the first place, limits the expansion and extension of the aneurism, but may finally increase to such an extent as to occupy the whole cavity and close up its mouth. This condition can only obtain in saccules with small mouths, and in vessels of the second magnitude, hardly ever in the aorta or larger trunks, the impetus of the blood-stream being too great to permit of the necessary deposit of fibrin. (*b*) It may arise as the result of the *sudden* coagulation of all the blood in the sac from the stoppage of the circulation, owing to the lodgment of an embolus either at the mouth of the aneurism or in the trunk immediately below. (*c*) The aneurism may become so large as to compress the main vessel, either going to or coming from it, thus bringing about its own cure. (*d*) Again, if the sac becomes inflamed, consolidation may occur with or without suppuration, although the latter process as will be seen anon, is attended with serious danger to life and limb.

The sac becomes more and more firm, the pulsation less forcible and distinct, the bruit diminishes, and finally consolidation is effected, a firm fibroid tumour alone remaining, which gradually shrinks, whilst the collateral circulation is opened up so as to supply the limb below. It is sometimes by no means easy to recognise the fibroid mass which results from a *consolidated aneurism*, and in making a diagnosis the history has mainly to be depended on. The existence of a tumour in the line of an artery, the probable occlusion of the main trunk, and the fact that the circulation is carried on by means of collateral branches, are the chief points which can be ascertained by a physical examination.

2. **Diffusion and Rupture** result from yielding of the walls of an aneurism, as an outcome of some mechanical injury or from simple over-distension.

When an **internal** aneurism gives way, the patient usually experiences a sensation of pain in the part, and becomes pale, cold, and faint, possibly dying within a few minutes or, at most, hours; or there may be a sudden gush of blood from the mouth if the trachea or œsophagus has been opened. Sometimes internal aneurisms leak slowly, and the final stage lasts some days.

When an **external** aneurism yields, it may do so slowly or quickly. If the blood becomes effused *slowly* (a *leaking* aneurism), the tumour gradually increases in size, and its outline is less clearly limited; the pulsation diminishes in force and distinctness. and the signs of pressure upon the veins or nerves become more urgent, until gangrene sometimes supervenes. If the sac yields *suddenly* (a *ruptured* aneurism), the patient experiences severe pain in the part which becomes tense, swollen, and brawny; all pulsation ceases, both in

the aneurism and below it, and gangrene of the limb follows, or even death from syncope, if the skin gives way. Suppuration may also occur in these cases.

3. **Suppuration** is an exceedingly serious, but by no means a usual, complication. It may arise in the following ways: (*a*) After ligature of the main vessel, especially when the wound becomes infected, and there is a good deal of loose cellular tissue around the sac, as in the axilla; (*b*) after diffusion, partial or complete, of an aneurism, where there is great tension upon surrounding parts. Auto-infection or the presence of an infective embolus may finally determine the suppurative process. The tumour shows signs of inflammation, becoming hot, red, painful, and swollen, and the skin over it may pit on pressure; whilst fever and general constitutional disturbance are also present. Sooner or later, if left to itself, the tumour points at one spot and bursts, giving exit to a mixture of blood-clot, pus, and a greater or less amount of bright red blood. The patient either dies at once from syncope, or a little later from secondary hæmorrhage and toxæmia, unless efficient treatment is adopted.

Treatment.—I. **General** treatment is employed as an accessory to surgical measures, or must be relied on entirely in cases where local means are impracticable, as in internal aneurisms.

In *plethoric* individuals, where the disease often runs a rapid course, absolute rest, both mental and physical, must be enjoined, with the removal of all sources of irritation and worry. The bowels should be kept gently open, and constipation and straining avoided. The heart's impulse may be diminished by the use of drugs, or even by venesection when it is very forcible. Iodide of potassium is usually prescribed, on account of the frequent association of aneurism with syphilis; and calcium lactate (grs. 5, t.d.s.) may be useful in increasing the coagulability of the blood. The diet must be suitably diminished, and only highly nutritious material allowed, and that mainly of the nitrogenous type, with as little fluid as possible (not more than about a pint a day).

In *weakly individuals*, whilst strictly enjoining a recumbent posture, the surgeon should prescribe iron and a somewhat more liberal diet, in order to improve the quality of the blood.

II. **Surgical Treatment.**—A. The ideal plan consists in dealing with the arterial wall so as to obliterate the aneurism, but without occluding the original lumen of the vessel, according to the suggestion of Matas* of New Orleans. This is obviously only possible in selected cases of sacculated aneurism, but a number of satisfactory results have been reported. The circulation is controlled temporarily, and the aneurism laid freely open, so that its interior can be emptied completely and carefully examined. The orifices of the smaller collateral branches are secured by purse-string sutures, and

* *Annals of Surgery*, February, 1903. Also Report of International Congress of Medicine, London, 1913, Section VII., part ii.

the margins of the main opening are approximated by a row of Lembert's sutures, if need be, over a piece of rubber catheter, which is subsequently removed, the continuity of the original vessel being thus restored, the aneurismal walls are brought together by superimposed rows of Lembert's sutures. It is probable that in many instances the artery becomes obliterated in spite of the surgeon's care.

In unsuitable cases, *e.g.*, fusiform aneurisms, the surgeon may operate with the intention of obliterating the cavity of the sac. The openings of the main vessel, above and below, are first secured from within, as also any smaller branches, and then the cavity is obliterated by rows of stitches as before. In neither of these plans must the sac be detached from its surroundings.

B. **Complete Extirpation** of the aneurismal sac, as if it were a tumour, may be looked on as the best method of treatment in the majority of cases. The limb is exsanguinated by elevation, and in suitable cases the aneurism is removed without opening it, and the vessel secured by ligature above and below, as also any branches which may arise from it. Sometimes, however, it is necessary to open it and turn out its contents before attempting its extirpation, which is often a matter of considerable difficulty owing to the adhesions present. Not unfrequently the vein will be encroached on in this dissection, and it may have to be removed; bad results are not likely to follow, since the pressure of the sac has already probably established an efficient collateral venous circulation. The results of this operation are most satisfactory, since the length of treatment is curtailed, and all chances of local recurrence are removed. Gangrene also is uncommon, since only one set of collateral circulation is called upon, viz., that required to bridge the gap made by removing the aneurism, whereas in the Hunterian operation a double set is needed, viz., at the site of the ligature, and round the consolidated aneurism. X 28/6/40. ([illegible])

C. The **deposit within the sac of fibrin,** which shall subsequently organize and thus lead to the obliteration of both sac and supplying vessel, was the ideal aimed at by the earlier surgeons, and has still to be relied on in many cases. It is obvious that a slow and gradual deposit of laminated fibrin is likely to be more satisfactory than the sudden distension of the sac with soft red clot.

The various plans adopted with this end in view are as follows:

1. **Compression** of the main vessels, usually on the proximal side of the aneurism, was much vaunted by the Dublin school of surgeons in the last century, and gave not a few good results. It may be applied either continuously or at intervals. If *intermittent,* the main vessel leading to the aneurism is controlled by means of fingers (digital compression), or by mechanical contrivances (such as a tourniquet or a conical bag filled with shot), for as long a period as the patient can bear, which usually does not exceed thirty minutes, especially if there is any nerve in the immediate neighbourhood. There seems to be no necessity to arrest completely the flow of blood through the sac, so long as the blood-pressure is sufficiently

diminished to permit of coagulation within it. *Continuous* pressure under an anæsthetic aims at the entire stoppage of the circulation through the sac, so as to allow not only of its contraction, but also in some instances of the rapid coagulation of its contents. Such pressure may be effected by the fingers of relays of dressers, taking shifts of ten to fifteen minutes at a time. It is well to arrange for some weight, such as a conical shot-bag, to rest upon the thumb or finger employed, so as to relieve muscular strain.

2. **Ligature** of the main vessels leading to or coming from the aneurismal sac must next be considered. The oldest procedure, the **Operation of Antyllus,** consisted in laying open the sac, turning out the clots, securing the vessel above and below, and allowing the wound to heal by granulation (Fig. 105, A). Performed, as it was originally, without antiseptics, it was naturally attended with great mortality from secondary hæmorrhage.

In **Anel's Method** (Fig. 105, B) the artery was tied just above the sac on the cardiac side, with no branch intervening; this also proved dangerous, since secondary hæmorrhage frequently resulted, either from suppuration within the sac, or from injury to the sac during the operation, or from yielding of the arterial wall at the site of ligature from septic peri-arteritis. At the present time it is not unfrequently undertaken successfully.

Hunter's Operation (Fig. 105, C), which consists of ligature of the main vessel on the cardiac side at some distance from the aneurism, was first performed by him in 1785. The object is not to cut off absolutely the blood-supply to the sac, but to allow the blood to enter it with a greatly diminished impulse, and in small amount at first, thus permitting of the contraction of the sac wall and of the gradual deposit within it of fibrinous clot, which in time becomes organized into a mass of firm fibroid tissue. It is desirable, though not essential, that no branch of large size should intervene between the point of ligature and the sac. The operation is *contra-indicated* (1) in cases where serious cardiac disease co-exists, or when an internal aneurism is also present, rendering undesirable any sudden increase of the blood-pressure, as by occlusion of a main vessel; (2) where pressure over the vessel does not control the circulation through the sac; (3) where the peripheral vessels are extensively calcified; (4) where gangrene of the limb is threatening or present, or (5) where bones or joints have been seriously involved.

Distal Ligature is only practised for aneurisms situated in positions where it is impracticable to deal with the artery on the cardiac side of the sac, such as the innominate, lower part of the carotid, or first part of the subclavian. **Brasdor's Operation** consists in tying the main trunk beyond the sac, so as totally to cut off the circulation through it (Fig. 105, D). In **Wardrop's Operation** a ligature is placed on one or more of the distal branches (Fig. 105, E). In the former the sac gradually contracts, and thus allows of the deposit of fibrin; in the latter proceeding, where the circulation is only partly controlled, the diminution of the size of the aneurism goes

on much more slowly, and the chances of the deposition of clot in the sac are correspondingly lessened.

It is not unusual, after the application of a ligature to a main artery for aneurism, to observe a **return of pulsation in the sac** after a day or two. In the majority of cases this only continues for a short time, and is by no means an unfavourable sign, indicating the re-establishment of the collateral circulation; but if it commences a week or ten days after the operation, it is more likely to persist. It is most frequently seen in cases where the main vessel has been tied at some distance from the sac, as in the superficial femoral for popliteal aneurism, and where one or more large and important collateral branches carry blood into the artery below the ligature or directly into the sac. The early recurrence of pulsation needs no *treatment* in most instances; but when it comes on at a later stage, it demands serious attention. Rest, elevation of the limb, and

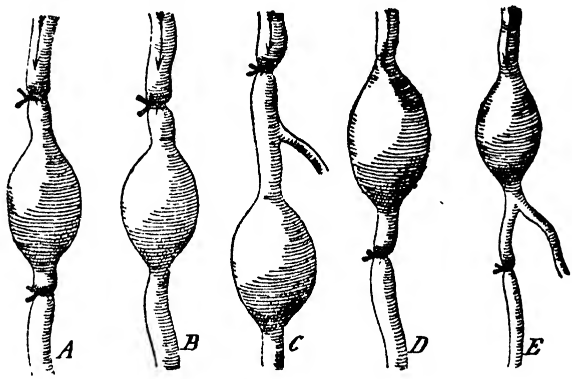


FIG 105.—METHODS OF APPLYING LIGATURES FOR ANEURISMS.
A, Method of Antyllus, *B*, Anel's operation, *C*, the Hunterian operation; *D*, Brasdor's operation; *E*, Wardrop's method.

judicious pressure over the trunk above the site of ligature, should first be tried. These failing, the following courses are open: (*a*) The artery may be again tied, either nearer the sac when feasible, or further away from it; (*b*) where the aneurism can be reached, it may be cut down on and dissected out, the best course to adopt if it be practicable; or (*c*) amputation just above the aneurism may be called for as a last resource.

3. **The Introduction of Foreign Bodies into the Sac** (*Moore's Method*) has not been followed by much success, although a few cases of abdominal aneurism seem to have derived temporary benefit from it. Steel wire has been usually employed; it is firmly wound round a cotton reel to give it a spiral coil, and inserted into the sac through a very fine cannula. Varying lengths from 10 feet to 26 yards have been introduced. An ingenious con-

trivance has been designed by Sir D'Arcy Power and Mr. Colt for this purpose. It consists of a fine wire wisp or cage, which can be introduced closed as a cartridge through a special cannula, and pushed by a ramrod into the sac, where it expands of itself umbrella-fashion, thereby exposing a large surface of wire on which coagulation can occur. Satisfactory results have attended its employment.

4. **Electrolysis** has been attended by some very happy results, but is so liable to be followed by leaking from the sac that it is now seldom used.

D. Quite distinct in principle from the preceding plans is that associated with the name of the late Sir William Macewen, who looked on blood-clot as undesirable material to work with for the cure of an aneurism, and directed his attention to thickening the walls of the sac to such an extent as to determine its occlusion, or to prevent its subsequent dilatation. To this end he employed **Acupuncture,** introducing several fine needles into the sac and leaving them to be played upon for a time by the blood-stream, so as to scratch and irritate the further wall of the sac, and thus cause an inflammatory hyperplasia, which will subsequently organize into dense fibro-cicatricial tissue. The process must be repeated as often as is considered necessary. In his own hands excellent results were obtained; but whilst admitting its value for internal aneurisms, we cannot but think that for those involving peripheral vessels other methods are more rapid and equally effective.

E. **Amputation** may be required in the treatment of aneurisms under a variety of circumstances: (*a*) When extensive gangrene of the limb has occurred or is imminent; (*b*) for diffusion or suppuration of an aneurism when everything else has failed; (*c*) for secondary hæmorrhage as a last resource; (*d*) in some cases of recurrent aneurism; (*e*) when joints have been opened or bones eroded to such an extent as to impair the utility of the limb; and, finally, (*f*) in a few cases of subclavian aneurism amputation at the shoulder-joint has been practised in order to diminish the amount of blood flowing through the sac.

The Treatment of a Diffuse Aneurism varies somewhat according to whether the diffusion is slow or rapid. In a *leaking* aneurism the main vessel leading to the swelling must be tied, if this has not already been undertaken, and the influence of this measure, combined with rest, elevation, and careful general treatment, observed. Should the process not be stayed, the case is treated as a diffuse or *ruptured* aneurism by laying open the sac, after exsanguinating the limb by elevation and the use of an elastic band, and securing, if possible, the main vessel above and below, as also any branches which may open into the sac, if they can be found. If there is any evidence of incipient gangrene, or if secondary hæmorrhage supervenes, amputation must be undertaken. In such cases everything will depend on the efficient maintenance of asepsis.

The **Treatment of an Inflamed Aneurism** is always a matter of

anxiety from the risk of recurrent and fatal hæmorrhage. If the main trunk has not been previously tied, this should at once be undertaken so as to reduce the blood-pressure in the sac, and the effect carefully watched; an ice-bag should also be applied to the part, and the limb elevated. If no good result follows, or if the artery has already been tied, nothing remains but to lay the sac freely open and endeavour to secure, by ligature, the main trunk above and below, as well as any smaller branches. Unfortunately, the walls are often soft and rotten, so that ligatures cut out; should bleeding supervene, amputation will be required.

Special Aneurisms.

Aneurism of the Thoracic Aorta is most commonly of the fusiform type in the early stages, but a limited sacculation often supervenes as the disease advances. The symptoms vary with the part affected. (1) In the *ascending part of the arch* the swelling rarely reaches a great size, especially if it is intrapericardial, the sac usually rupturing before marked pressure signs are evident.

(2) When arising from the *transverse part of the arch*, the symptoms vary with the direction taken by the enlargement. If it projects *upwards*, a pulsating tumour may appear at the episternal notch, and cerebral effects may then ensue from interference with the circulation through the carotids, or from pressure on the venous trunks. If it extends *anteriorly*, it may form a large pulsating tumour to the right of the sternum with comparatively slight pressure effects, except the pain arising from its erosion of the thoracic wall. If the enlargement takes place either *posteriorly* or *downwards* within the concavity of the arch, symptoms of dyspnœa and dysphagia are early produced from the close contiguity of the trachea, œsophagus, and pulmonary vessels. Pressure upon the left recurrent laryngeal nerve, as it passes round the aorta, results in spasm of the laryngeal muscles, especially of the crico-arytenoideus posticus, producing suffocative attacks of dyspnœa and a loud metallic or brassy cough, which is very characteristic. At a later date the nerve is paralyzed, and then the voice becomes affected, and the vocal cord fixed and immobile, but without serious dyspnœa. Laryngeal or tracheal stridor may be noticed in these cases, and a dragging down of the trachea synchronous with the heart's action (the so-called 'tracheal tug'). Radiographic examination is a valuable means of diagnosis, since the aneurism gives a dark shadow on the screen or plate.

(3) Aneurisms of the *descending arch* and *thoracic aorta* often attain considerable dimensions, and may project posteriorly to the left of the vertebral column, causing a pulsating swelling. The only prominent symptoms are pain, due to erosion of ribs or vertebræ, and interference with deglutition, which may be so great as to suggest the presence of an œsophageal constriction; in fact, before a bougie is passed in any case of dysphagia it is always advisable to make certain by radiography that an aneurism is not present.

Treatment.—Little can be done beyond ordinary medical measures, such as rest, diet, and the administration of iodide of potassium. When the aneurism projects in front, the introduction of coils of iron wire or of Colt's apparatus has been employed with some success.

Ligature of the right carotid and right subclavian, or of the left carotid alone, has been adopted in cases of aneurism of the ascending aorta or of the arch. A certain amount of improvement followed some of the operations, but it is quite possible that this was as much due to the enforced rest in bed as to the operation.

Innominate Aneurism is usually of the tubular variety, and frequently associated with a similar enlargement of the aorta. It presents a pulsating tumour behind the right sterno-clavicular articulation—*i.e.*, between the heads of origin of the sterno-mastoid—projecting either into the episternal notch or outwards into the subclavian triangle, and perhaps pushing the clavicle forwards. The *pulse* in both the right temporal and radial arteries is diminished; *œdema* of a brawny character of the right side of the head and neck, and of the right arm, is caused by pressure on the right innominate vein, whilst less commonly similar changes on the left side may follow compression of the left vein or of the superior vena cava; *pain* shooting into the neck and arm is often produced by implication of the brachial nerves; hyperæmia and sweating of the right side of the face with dilatation of the right pupil may result from irritation of the sympathetic trunk. *Dyspnœa* is induced by direct pressure on the trachea, which may be displaced or flattened, or by compression of the right recurrent laryngeal nerve. *Dysphagia* occurs from pressure on the œsophagus. The course of the case is slowly progressive, and death most commonly results from asphyxia or from rupture of the sac.

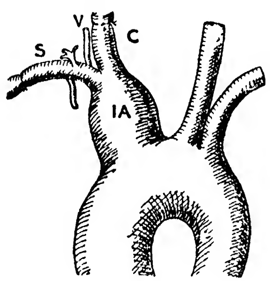


Fig. 106.—Application of Ligatures for Innominate Aneurism.

IA, Innominate aneurism; S, subclavian artery; C, carotid; V, vertebral artery.

Treatment.—Rest and the administration of large doses of iodide of potassium may cause improvement, but distal ligature is the most hopeful proceeding. It is obviously impossible to cut off all the blood passing through the sac to the three main divisions—viz., the carotid, subclavian, and vertebral—with safety to the patient (Fig. 106). Ligature of any one of these by itself offers but little prospect of improvement.

Aneurism of the Common Carotid is usually situated at the upper part of the trunk near the bifurcation, and more often on the right than on the left side. The root of the right carotid is also not unfrequently dilated, but the intrathoracic portion of the left carotid is rarely affected, except in conjunction with the aorta. No other external vessel is so frequently the seat of aneurism in women. The

ordinary intrinsic *signs* of an aneurism are present, and the pressure symptoms are mainly referable to interference with the cerebral circulation, to irritation of the cervical sympathetic trunk, or to pressure upon the larynx, pharynx, or trachea. The progress of these cases is usually slow.

Diagnosis.—(1) *From similar disease at the root of the neck* the distinction is often made with difficulty, since either an aortic, innominate, or subclavian aneurism may push upwards so as to simulate it somewhat closely. Percussion and auscultation of the upper part of the chest, together with a careful investigation into the history of the case, and a digital examination of the limits of the pulsating mass, may suffice to determine the point. The *pressure effects* must also be carefully considered. 'Pressure on the left recurrent laryngeal nerve would distinguish an aortic aneurism from one on the right vessels; pressure on the right nerve in like manner excludes an aortic aneurism. Pressure on the left innominate vein indicates aortic aneurism rather than innominate; compression of the internal jugular or subclavian vein only points to carotid or subclavian aneurism. A "tracheal tug" indicates an aneurism of the aorta' (Pearce Gould). The differences in the *peripheral pulses* in the radial and temporal arteries may also give useful information. If the left radial pulse is alone aneurismal, the root of the left subclavian is diseased, whilst if the left temporal is also affected, it suggests an aneurism of the transverse part of the arch beyond the innominate. When both radial and temporal vessels on the right side show signs of interference with the pulse, innominate aneurism is probably present, whilst an affection of only one of these branches indicates that the corresponding carotid or subclavian is dilated. One source of fallacy must not be forgotten, viz., that any one of these trunks may be occluded or compressed by a neighbouring aneurism without being dilated, and hence the quality of the pulse must be taken into consideration rather than its actual volume, and to this end the sphygmograph is a useful adjunct in diagnosis. (2) From *abscess, tumours, or enlarged glands* with a transmitted impulse, a carotid aneurism is recognized by an application of the general principles detailed above (p. 354). (3) *Pulsating or cystic goitre* may be distinguished from a carotid aneurism by noting that the goitre is not as a rule limited to one side of the neck, the isthmus being also involved; that the most fixed part of the tumour is in the median line, and not under the sterno-mastoid muscle; and that the swelling moves up and down during deglutition, an aneurism remaining fixed. (4) An aneurism close to the bifurcation may be simulated by an *abnormal arrangement of the terminal branches*, the external carotid crossing the internal from behind forwards, and being pushed outwards sufficiently to cause a pulsating swelling beneath the skin. This condition is usually symmetrical, and can be recognized by careful palpation.

Treatment.—*Ligature* of the carotid above or below the omo-hyoid is the treatment usually adopted, and generally with great success.

If the aneurism is near the root of the neck, the distal operation (Brasdor's) must be undertaken.

Aneurism of the External Carotid is seldom met with, except as an extension of one involving the bifurcation. The usual phenomena are presented near the angle of the jaw, and well above the thyroid cartilage. Pressure results are early experienced, *e.g.* paralysis of one side of the tongue through implication of the hypoglossal nerve (Fig. 130), aphonia, or dysphagia. In suitable cases, the sac may be dissected out after securing the branches arising from it; failing this, the common trunk must be tied.

Aneurism of the Internal Carotid (extracranial portion) presents symptoms which closely resemble those caused by an aneurism of the bifurcation or of the external carotid, except that the swelling projects more into the pharynx, from which it is separated merely by the pharyngeal wall. It appears as a tense pulsating tumour, placed immediately under the mucous membrane, and looking dangerously like an abscess of the tonsil. The **Treatment** consists in tying the common carotid.

Intracranial Aneurism occurs more commonly upon the internal carotid and its branches than upon those arising from the vertebrals, although the basilar artery is more often affected than any other single vessel. The aneurisms are generally fusiform in character, and their origin is often obscure, being attributed to a blow or fall; in children they are stated to result from the lodgment of infected emboli. They sometimes cause no symptoms until the patient is suddenly seized with a rapidly fatal apoplexy from rupture of the sac. Symptoms, if present, are due rather to compression of the brain than to erosion of the more resistant bony structures. Pain which is more or less fixed and continuous may be complained of, or there may be a feeling of pulsation, or of opening and shutting the top of the skull. Sight, hearing, and other functions of the brain, may also be impaired, but physical changes in the eyes, such as optic neuritis or atrophy, are not induced, unless there is direct pressure on some part of the optic tract. Occasionally a loud whizzing bruit may be heard on auscultating the skull. The only **Treatment** possible, if a diagnosis can be established, is ligature of the internal carotid artery, and even this will be of little use if the basilar is affected.

Orbital Aneurism.—Protrusion of the eyeball, together with pulsation (Fig. 107), which can be felt or even seen (*pulsating exophthalmos*), is always an indication that some vascular lesion is present within the orbit. (*a*) It is occasionally *congenital*, and then probably due to the presence of a deep cavernous angioma. (*b*) It is most frequently *traumatic* in origin, resulting from a penetrating wound, or a blow on the head, which may have caused a fracture of the base of the skull; in these the lesion present is generally an aneurismal varix between the internal carotid and the cavernous sinus. (*c*) It may be *non-traumatic*, and result from an aneurism of the ophthalmic artery, or from thrombosis of the cavernous sinus.

The patient complains of intra orbital pain and tension, the conjunctival and retinal vessels are distended, and a marked bruit may be present on auscultation. The movements of the eyeball are limited, vision is impaired, and the cornea may become opaque from exposure; finally, the whole globe may be disorganized.

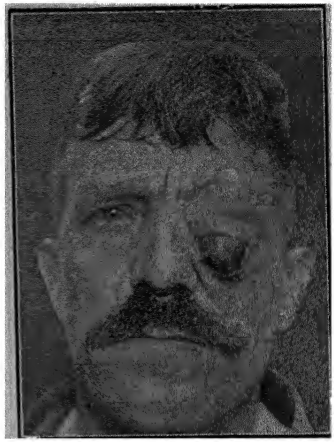


FIG 107—PULSATING EXOPHTHALMOS FROM TRAUMATIC INTRA ORBITAL ARTERIO-VENOUS ANEURISM

Diagnosis.—Sarcoma of the orbital wall may exhibit many of the characters of intra-orbital aneurism. Careful palpation will, however, generally demonstrate the existence of a definite tumour; the pulsation, moreover, is less marked, and the bruit less distinct. The distortion of the eyeball and ocular axis is often considerable in malignant tumours, but vision is not so early affected.

Treatment.—Ligature of the internal carotid is the only means which holds out any prospect of benefit, except in the congenital cases, where electrolysis has been very successful.

Subclavian Aneurism is most frequently seen in men, and particularly in those who carry weights on their shoulders; the right vessel is more often affected than the left. Any part of the artery may be involved, but the greatest dilatation naturally occurs in the third portion. A pulsating tumour develops in the subclavian triangle, which may project above the clavicle, but often extends backwards, outwards, and downwards, causing pressure effects upon the veins and nerves of the arm, and also hiccough by irritation of the phrenic. Occasionally it encroaches on the dome of the pleura and apex of the lung, and has been known to burst into the pleural cavity. It does not increase in size very rapidly, being surrounded by dense unyielding structures, and never compresses the trachea or œsophagus.

The **Treatment** of subclavian aneurism is surrounded with difficulties, and the results hitherto obtained have been most unsatisfactory. *Extirpation* has been undertaken with success, with or without turning up the middle third of the clavicle, as also Matas' operation, but the aneurism is seldom sufficiently limited to allow of these proceedings. *Ligature of the innominate trunk* suggests itself as the operation to be adopted for cure by the Hunterian method, and recent records would certainly encourage one to repeat it in any suitable case, combined with simultaneous ligature of the carotid, so as to avoid backflow of blood. *Ligature of the first part of the subclavian* is occasionally possible, and a few successful cases have

now been reported, although the first nineteen cases in which it was attempted died.

Axillary Aneurism is usually the result of falls on the outstretched arm, or injuries to the shoulder, such as fractures or dislocations, or of attempts to reduce them. A pulsating tumour develops, and its pressure causes pain, local and neuralgic, or œdema of the arm. When the upper part of the vessel is affected, the pulsation is felt immediately below the clavicle, and may project up into the neck, displacing the clavicle forwards; if placed lower down, the aneurism occupies the axilla. The progress of the case is often rapid, and the thoracic cavity may even be encroached on. **Treatment.**—Compression (digital) or ligature of the third part of the subclavian artery is required, but if the aneurismal sac extends under the clavicle, it may be necessary to secure the second part of the artery, due care being taken of the phrenic nerve.

Aneurisms of the brachial artery, or of any of the vessels of the forearm, require no special notice. They are almost invariably traumatic in origin, and should be treated by extirpation.

Abdominal Aneurism.—The abdominal aorta may become the seat of aneurism, either at the upper part near the cœliac axis, or at the bifurcation. A pulsating tumour is observed near the middle line, and either close to the umbilicus or in the epigastric notch; the pulsation is expansile in type, and remains the same in character whatever the position of the patient. Pain, localized in the back from erosion of the vertebræ, or neuralgic from pressure on the solar plexus or lumbar nerves, is the chief symptom, whilst œdema of the lower extremities may arise from compression of the vena cava. There may be some concurrent derangement of the intestinal functions. Occasionally aneurisms form independently on the splenic, hepatic, or mesenteric vessels. **Diagnosis.**—Many conditions give rise to epigastric pulsation. Cardiac pulsation may be felt in the epigastrium when the heart is dilated, but should be easily recognized; as also an impulse transmitted from the aorta through a collection of fæces or a cancerous growth.

Treatment.—Failing medical treatment by rest and diet, *compression* was formerly relied on, being applied either on the distal or proximal aspect of the sac. The method is, however, clumsy and liable to bruise the abdominal viscera. The introduction of Colt's appliance may be attempted. X 4\7\40

Iliac or **Inguinal Aneurism** arises from either the common or external iliac, or from the common femoral; it is frequently sacculated in type and lobulated in shape owing to the pressure of fascial or other structures. The symptoms are very typical, and diffusion is certain to ensue sooner or later. The **Diagnosis** cannot be well mistaken in the early stages, but later on, and specially when situated high in the iliac fossa, it may be difficult to distinguish from a pulsating sarcoma. **Treatment.**—*Extirpation* is, of course, the best plan to adopt if it be possible, but more frequently one must depend on proximal *ligature*. For an inguinal aneurism, the external iliac

may be tied with every prospect of success. If the aneurism is situated higher, ligature of the common iliac may be undertaken (transperitoneal operation), or even of the aorta. The latter operation has been performed in ten instances, and in all a fatal result followed, although two patients lived thirty-nine and forty-eight days respectively. Failing any of these methods, *compression* of the aorta or common iliac may be employed.

Aneurisms of the Gluteal and Sciatic Arteries are usually traumatic in origin, and present as pulsating swellings in the buttock, the gluteal situated at the upper part of the sciatic notch, whilst the sciatic lies more deeply, and may be partly intrapelvic. Pain in the limb from pressure on the sciatic nerve is a prominent symptom, especially in the sciatic variety. The **Diagnosis** is by no means easy, especially from a pulsating sarcoma. **Treatment.**—When the diagnosis is established, transperitoneal ligature of the internal iliac artery should always be adopted. If the sac is laid open from the buttock as a result of a mistaken diagnosis, the old-fashioned plan of treatment must be followed, viz., to turn out the clots and secure the bleeding-points.

Femoral Aneurism is the title given to one forming in the course of the superficial femoral artery. It is not uncommonly tubular, and occurs almost invariably in males. **Treatment** consists either in extirpation, or ligature of the common or superficial femoral trunk.

Popliteal Aneurism occurs almost invariably in men, constituting a pulsating tumour in the ham, rendering the knee painful and stiff, and so much do the symptoms resemble those of chronic rheumatism that in every such case the popliteal space should be examined. The limb is usually kept semiflexed, and the aneurism often increases rapidly in size. If the main swelling is situated in front of the vessel, there is some likelihood of the knee-joint becoming implicated and neighbouring bones carious; when it extends posteriorly, diffusion is not uncommonly followed by gangrene, on account of the pressure exercised, not only upon the vein, but also upon the articular branches of the popliteal artery, which are most important factors in maintaining the collateral circulation. The **Diagnosis** has to be made from chronic enlargement and abscess of the popliteal glands; but in these there is less disturbance of the circulation in the foot; from bursal tumours, by their want of mobility and pulsation; or from solid tumours, *e.g.* pulsating sarcoma of the femur or tibia, by attention to the general principles already enunciated.

Treatment.—Compression has been eminently successful in many of these cases. Ligature of the femoral artery at the apex of Scarpa's triangle is, however, the plan most commonly adopted, and with the greatest success. In cases where either of these methods has failed, or where the aneurism has become diffuse or recurred, extirpation of the sac is the best course to adopt.

Ligature of Vessels.

This operation is performed to arrest the flow of blood to the periphery, in order either to check hæmorrhage, or to promote the cure of an aneurism, or to diminish the rate of growth of some tumour, or to influence beneficially some peripheral organ by reducing its blood-supply, or as a preliminary to removing some vascular structure, such as the tongue.

Operation.—The artery is examined as far as is possible, so that a healthy portion may be selected for applying the ligature. The various structures (*rallying-points*) met with on the way to the artery are recognized, and drawn aside, if need be, so as to lay bare the sheath of the vessel, which is opened over the artery by a longitudinal incision about ¾ inch in length. The aneurism needle is inserted unarmed, and gently manipulated up and down, so as to free the vessel all round, a matter of no great difficulty if the sheath has been correctly opened and the arterial wall exposed. The ligature may then be passed through the eye of the needle, and carried round the vessel, tied in a direction exactly at right angles to the longitudinal axis; in doing so the artery must not be dragged out of its sheath, but the ligature should be tightened by the tips of the forefingers meeting upon it. The opening in the sheath should be closed over the ligature by a fine buried stitch, and the various structures displaced in reaching the vessel are similarly secured in good position.

Method of Application of the Ligature.—In the smaller vessels and those of medium size all that is needed for security is a **reef** knot tied firmly; but in the largest trunks—*e.g.*, the innominate, first part

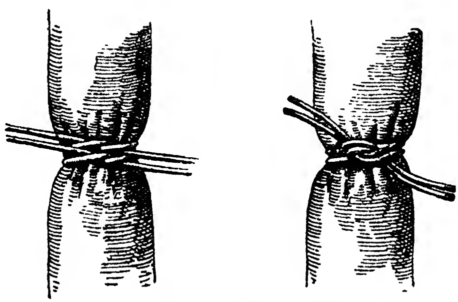


FIG. 108.—STAY KNOT.

of the subclavian, and common iliac—it is advisablé to employ what is termed the **stay knot** (Fig. 108). Two strands of ligature are passed round the vessel side by side and half-knottėd; the two ends on each side are then taken up together and tied across in one knot. The degree of tension is such as to approximate completely the vessel walls, but without rupturing the inner or middle coats, thereby minimizing the risks of secondary hæmorrhage.

The rule usually followed is to pass the needle *from important structures, such as the vein,* but really this is a matter of little significance when the above directions have been carefully carried out, and especially in superficial vessels. *Should the vein be accidentally punctured,* the needle must be at once withdrawn and the puncture in the vein secured by ligature, whilst the artery is tied a little higher or lower. In dealing, however, with the smaller vessels, where the venæ comites are in close contact with the arteries, no harm will attend their inclusion in the ligature.

After-Treatment.—The patient must be kept at rest for at least three weeks in order to secure permanent obliteration of the artery and the effective development of a collateral circulation, especially in dealing with the larger vessels and in elderly people. When the main artery to one of the extremities has been tied, the limb should be wrapped in aseptic wool and slightly raised, and if there is any likelihood of gangrene, it should be thoroughly purified.

There are two great **dangers** liable to follow the ligation of an artery in its continuity.

1. **Secondary Hæmorrhage** (*vide* p. 333).

2. **Gangrene** may arise from a variety of causes: (*a*) From simple loss of vitality, owing to a defective collateral circulation, as when the peripheral vessels are calcareous and rigid. The tissues which receive the smallest amount of blood die first—*e.g.*, the fingers or toes, or the subcortical white substance of the brain. Severe loss of blood after the operation, as from secondary hæmorrhage, may also determine tissue necrosis. Under such circumstances it almost always takes on the dry form. (*b*) Interference with the venous return, as by injury to the vein during operation, or the pressure of a tight bandage, or thrombosis induced subsequently by infective periphlebitis, was formerly supposed to render the limbs more liable to gangrene, but recent experience has contradicted this idea, and it is possible that simultaneous ligature of the vein may hinder rather than predispose to gangrene by limiting the vascular back-pressure in the limb (p. 125). (*c*) Unsuitable after-treatment, such as too great elevation of the limb, the injudicious application of an ice-bag or hot-water bottle during the period of diminished vitality immediately following the operation, or even an attack of erysipelas, may also bring about the death of some of the tissues. The **Treatment** of aseptic gangrene following ligature is expectant in character, the parts being allowed to separate naturally. If, however, there is much pain or any tendency to spread, or if infection is present, giving rise to fever and general disturbance, it is wiser to remove the limb well above the line of demarcation.

The **Innominate Artery** has now been tied with success on at least six occasions out of a total of about thirty operations. For details textbooks on operative surgery must be consulted.

Collateral Circulation.—Intracranial: Vertebrals and carotids in the circle of Willis.

Face and Neck: Branches of the two external carotids across the middle line.

Trunk: First aortic intercostal *with* superior intercostal of subclavian; upper

aortic intercostals *with* thoracic branches of axillary and intercostals of internal mammary; deep epigastric and phrenic *with* terminal divisions of internal mammary.

The **Carotid Artery** may be tied either above or below the level at which it is crossed by the anterior belly of the omo-hyoid. The line of the vessel is indicated by that drawn from the sterno-clavicular articulation to a point midway between the angle of the jaw and the tip of the mastoid process, the bifurcation being on a level with the upper border of the thyroid cartilage.

Ligature above the Omo-hyoid.—The vessel is here more superficial, and the ligature is applied on a level with the cricoid cartilage. The patient lies upon the back, with the chin raised and the head turned towards the opposite side A 3-inch incision is made in the line of the vessel, the centre on a level with the cricoid (Fig. 109, C). The skin, platysma, and fasciæ are divided, and the anterior edge of the sterno-mastoid defined The deep fascia is incised along its inner border, so that it may be drawn aside by a retractor; the sterno-mastoid branch of the superior thyroid artery may be divided at this stage. On the inner side of the wound the omo-hyoid muscle must now be looked for, trending forwards and upwards from under cover of the sterno-mastoid In the angle formed by these two structures the pulsation of the vessel should be felt and the sheath readily recognized, with the descendens cervicis nerve upon it. It is opened on the inner side, and the artery well cleared. The needle is passed from without inwards, and if the sheath has been efficiently opened, the vagus nerve will run no risk of being included.

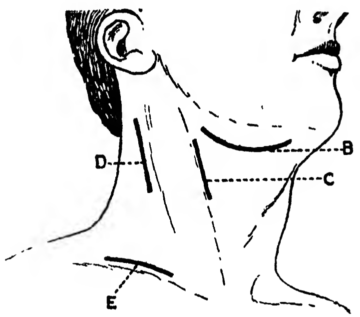


FIG. 109.—INCISIONS FOR OPERATIONS ON VESSELS OF THE NECK.

B, Incision for ligature of lingual artery; C, for ligature of common carotid; D, for operations on posterior triangle—*e g.*, for ligature of vertebral artery; E, for ligature of the third part of the subclavian.

Ligature below the Omo-hyoid.—A similar incision is made, but lower in the neck, reaching from the cricoid cartilage nearly to the sterno-clavicular joint. The sterno-mastoid is drawn outwards, and perhaps the anterior fibres may need to be divided; the sterno-hyoid and thyroid muscles are retracted inwards or divided, and the omo-hyoid can usually be drawn upwards. The sheath is thus exposed, and opened on the inner side, the needle being passed as in the previous operation. It must be remembered that both internal jugular veins are directed towards the right side in the lower part of their course, and hence the left vein is likely to lie somewhat in front of the artery. The inferior thyroid veins may also be seen, and need to be drawn aside or ligatured.

The *effects* of ligature of the carotid upon the brain are of great interest and importance. Statistics prove that about 25 per cent of the patients develop cerebral symptoms, either immediately in the form of syncope from cerebral anæmia, or in the course of a few days from cerebral softening, causing hemiplegia. A fatal issue is likely to result in about half the cases thus affected.

Collateral Circulation.—Intracranial : Circle of Willis.

Extracranial : Communications across the middle line of branches of the external carotids and vertebrals; inferior thyroid *with* the superior thyroid; profunda cervicis *with* princeps cervicis of occipital; superficial cervical *with* branches of occipital and vertebral.

Ligature of the Internal Carotid.—An incision is made along the anterior border of the sterno-mastoid, its centre being opposite the great cornu of the hyoid bone; the muscle is pulled backwards, and the posterior belly of the digastric is seen and drawn up. The external carotid is displaced forwards,

and then the internal carotid in its sheath appears. The latter is opened, and the aneurism needle passed from the jugular vein.

The *Collateral Circulation* to the brain is maintained by the circle of Willis.

Ligature of the External Carotid is occasionally required, the site of election being between the superior thyroid and lingual branches. An incision is made along the anterior border of the sterno-mastoid, 3 inches in length, its centre corresponding to the great cornu of the hyoid bone. The edge of the muscle is defined and drawn outwards, and the posterior belly of the digastric sought for above, the hypoglossal nerve lying just below it. The sheath is now opened below the tip of the great cornu, and the needle passed from without inwards. The operation may be rendered difficult by the presence of enlarged glands or veins, especially the lingual, facial, and superior thyroid, which lie in front of the vessel. The superior laryngeal nerve is placed immediately behind it, and must be avoided.

Collateral Circulation.—Vide ligature of the common carotid (extracranial portion).

Ligature of the Lingual Artery may be employed as a preliminary to removal of the tongue for malignant disease. The vessel can be secured either

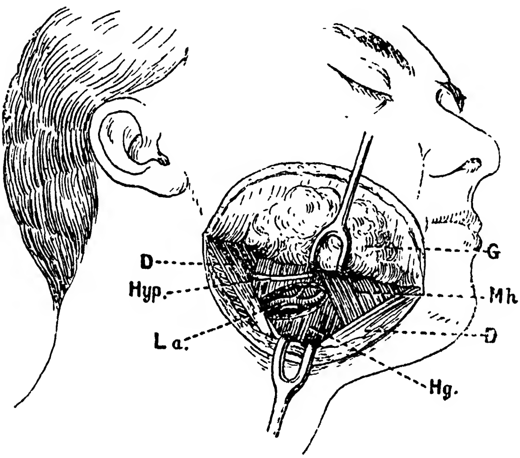


FIG. 110.—LIGATURE OF LINGUAL ARTERY.

The submaxillary gland (G) has been drawn over the side of the jaw with a hook; D, digastric; Hyp., hypoglossal nerve; Mh., mylo-hyoid, Hg., hyoglossus; L a., lingual artery. The place where the artery is tied is indicated by a window in the hyoglossus, through which it can be seen.

close to its origin from the external carotid, or in the submaxillary triangle under cover of the hyoglossus muscle.

In the Submaxillary Triangle.—The patient lies on his back, with the shoulders raised, and the head extended backwards and turned to the opposite side. A crescentic incision with its convexity downwards is made, commencing about 1 inch below the symphysis menti, and extending back to the sterno-mastoid, the centre opposite the great cornu of the hyoid bone (Fig. 109, B). The integument and platysma are divided, the lower border of the submaxillary gland is defined, and along it the deep fascia is incised. The gland is now drawn upwards and held over the margin of the jaw with a retractor (Fig. 110, G). On opening up the wound thoroughly the two bellies of the digastric muscle (D) are seen converging to the hyoid bone, the anterior belly passing superficial to the fibres of the mylo-hyoid muscle (Mh.), which course nearly transversely to the mandible and of which the posterior fibres

may be divided with advantage. The digastric tendon is drawn down with a blunt hook, and in the space thus cleared the hyoglossus muscle (Hg.) becomes evident with its fibres passing vertically upwards, and resting upon it the hypoglossal nerve (Hyp.) coursing forwards to get under cover of the mylo-hyoid, and either above or below it the ranine vein. The fibres of the hyoglossus are now divided transversely midway between the nerve and the hyoid bone, and in the opening made by their retraction is seen the artery (L.a.), lying on the middle constrictor. Should it not be found in this situation, the incision in the hyoglossus should be extended backwards, and the vessel will then usually come in sight.

In the Neck Close to its Origin.—An incision is made along the anterior border of the sterno-mastoid similar to that needed for ligature of the external carotid. The muscle is drawn backwards, and the great cornu of the hyoid bone defined. The small space is now cleared between that bony process and the posterior belly of the digastric, in which the artery can be felt resting upon the middle constrictor, and secured just as it rises from the external carotid.

The **Facial Artery** may be exposed and tied through a horizontal incision, 1 inch in length, made directly over the vessel as it crosses the lower border of the jaw immediately in front of the masseter.

The **Temporal Artery** is reached in front of the auditory meatus through a vertical incision, and must be carefully isolated from the auriculo-temporal nerve.

The **Occipital Artery** is tied through an incision extending from the apex of the mastoid process backwards for about 2 inches towards the occipital protuberance. The posterior fibres of the sterno-mastoid, the splenius, and trachelo-mastoid, are divided so as to expose the artery as it emerges from the groove on the under surface of the mastoid process, where it is easily secured.

The **Subclavian Artery** has been tied in each part of its course, but most frequently in the third. Ligatures of the first and second parts are such unusual proceedings that we must refer students to larger textbooks for descriptions.

For *ligature of the third part* the patient is placed on the back, close to the edge of the table; the arm is well depressed, and the head turned to the opposite side. The skin is drawn down by the left hand, and an incision 3 or 4 inches long made over the clavicle (Fig 109, E). On releasing the skin it retracts upwards, so that the wound comes to be situated about ½ inch above the clavicle, and thus the external jugular vein is more efficiently protected. The incision should be placed with its centre about 1 inch to the inner side of the middle of the clavicle, and should expose the space between the sterno-mastoid and trapezius muscles, the fibres of which are divided to a suitable extent if they encroach abnormally upon the bone. The external jugular and other veins often give the surgeon much trouble; they are either drawn aside or, if necessary, divided between ligatures. The deep fascia is incised in the line of the wound, care being taken to avoid the transverse cervical and suprascapular arteries, the former of which is above the line of operation, whilst the latter is hidden behind the clavicle. The posterior belly of the omo-hyoid, if seen at all, is drawn upwards. Various layers of fascia must be carefully cut or torn through until the nerves of the brachial plexus appear; the finger can then readily define the scalene tubercle on the first rib. The subclavian vein is situated in front of the finger, but on a lower level, whilst the artery itself can be detected pulsating under the pulp of the finger between it and the rib. The cords of the brachial plexus are placed above and external to it, the lower cord passing down behind. The needle is insinuated from above downwards, and must be kept very close to the artery to prevent all possibility of including the lowest cord of the plexus. The operation in a thin patient may be easy, but in a stout subject, with a short thick neck and high clavicle, the greatest difficulty may be experienced in finding the vessel. The chief dangers arise from wounding the pleural cavity, or the superficial veins, or from ligaturing one of the cords of the brachial plexus.

Collateral Circulation.—Thoracic set : Branches of the aortic intercostals and internal mammary *with* thoracic branches of axillary.

Scapular set : Suprascapular and posterior scapular *with* subscapular and its dorsalis branch in the venter or on the dorsum of scapula.

Acromial set : Suprascapular *with* acromio-thoracic.

The **Internal Mammary Artery** may be exposed and tied by dividing the intercostal aponeurosis and muscles for an inch or more from the outer edge of the sternum, from which it is distant about ½ inch.

Ligature of the Vertebral Artery has been undertaken for wounds, for secondary hæmorrhage after ligature of the innominate, and in the treatment of epilepsy, but without much permanent benefit in the last case. An incision is made along the lower half of the posterior border of the sterno-mastoid (Fig. 109, D), the platysma and deep fascia are divided, and the muscle drawn forwards. The scalenus anticus is clearly defined, together with the phrenic nerve. The interval between it and the longus colli muscle can now be demonstrated, with the ascending cervical artery lying upon it. The anterior transverse process of the sixth cervical vertebra must be made out. Just below this the vertebral vessels are found entering the canal in the transverse process, and the vein, which is placed anteriorly, is drawn outwards to allow the needle to be passed from without inwards. A few sympathetic twigs are often included in the ligature, and may cause contraction of the pupil.

Ligature of the Thyroid Vessels is sometimes used in the treatment of exophthalmic goitre (*q.v.*).

The **Axillary Artery** is tied for punctured wounds of the axilla, as a distal operation for subclavian aneurism, occasionally for wounds of the palmar arch, and possibly for secondary hæmorrhage from the brachial. Two classical operations are described and practised in classes on operative surgery.

1. *Ligature of the first part of the vessel* is usually undertaken through a curved incision, with its concavity upwards, extending from the coracoid process to just below the sterno-clavicular joint. The clavicular origin of the pectoralis major is divided, and the costo-coracoid membrane exposed and divided. Branches of the acromio-thoracic axis are displaced, and the main trunk is exposed by a blunt dissector and forceps. The vein lies within and below, and the cords of the brachial plexus above and to the outer side. The divided muscular fibres should be subsequently sutured together.

An incision which gives an unusually good approach and involves less division of muscular fibres is one which follows the lower border of the clavicle from its centre outwards to the coracoid process, and then turns down to lie over the interspace between the pectoralis major and deltoid muscles. This intersection is opened up, and the outermost fibres of the pectoralis which arise from the clavicle are divided. The costo-coracoid membrane is thus exposed, and the cephalic vein will act as a guide to the vessels.

2. *Ligature of the third part of the artery* is performed from the axilla. The arm is fully abducted, and the surgeon stands between it and the body. An incision is made in the course of the vessel (Fig. 111, A). The inner border of the coraco-brachialis muscle is clearly defined, and drawn slightly outwards, and the median nerve, together with the musculo-cutaneous trunk, at once comes into view. On drawing these inwards, the artery itself is seen, with the vein to the inner side. The needle is passed from the vein.

Collateral Circulation.—If above the acromio-thoracic, the same as for the third part of the subclavian (*q.v.*).

If above the subscapular and circumflex: Long thoracic and intercostals *with* thoracic branches of subscapular; suprascapular and posterior scapular *with* scapular branches of subscapular; suprascapular and acromio-thoracic *with* posterior circumflex in the deltoid.

If below the circumflex, same as for ligature of brachial above the superior profunda—*i.e.*, posterior circumflex *with* superior profunda in the deltoid.

The **Brachial Artery** may need to be ligatured for hæmorrhage from the palmar arches, or from a wound in the forearm or about the elbow, for aneurisms, or for arterio-venous wounds at the bend of the elbow. It may be tied in one of two places:

1. *At the Middle of the Arm.*—The arm is held away from the side at a right angle, with the hand supine, but with no support beneath it, for fear of pushing

forwards the triceps and displacing the vessel. The surgeon stands between the arm and the trunk. An incision 2 inches long is made in the line of the vessel along the inner border of the biceps muscle (Fig. 111, B), and the thin fascial investment of the limb divided. The inner edge of the muscle is clearly exposed, and by drawing it slightly forwards the median nerve is brought into view, and perhaps the basilic vein. The nerve, which is at this spot crossing the artery from without inwards, is drawn inwards, and the sheath of the vessel found beneath it. The artery is separated from its venæ comites, and the ligature passed and tied.

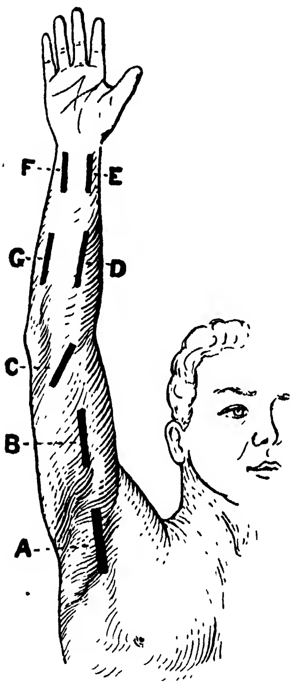


FIG. 111.—INCISIONS FOR TYING THE ARTERIES OF THE ARM.

A, Third part of the axillary, B, brachial; C, brachial at the bend of the elbow; D, middle third of radial; G, middle third of ulnar; E and F, lower thirds of radial and ulnar.

2. *At the Bend of the Elbow.*—An oblique incision is made, about 2 inches long, parallel to the inner border of the biceps tendon, its lower end corresponding to the crease of the elbow (Fig. 111, C). The incision should be placed at an angle of forty-five degrees to the axis of the limb, and to the outside of, and nearly parallel to, the median basilic vein, which, if seen, must be drawn inwards. The bicipital fascia is now incised, and the artery with its venæ comites exposed in the loose fat, the median nerve being well away on the inner side.

Collateral Circulation.—If above the origin of the superior profunda, posterior circumflex in deltoid *with* ascending branches of superior profunda.

If below the origin of the inferior profunda, the anastomoses around the elbow-joint.

The **Ulnar Artery** rarely needs ligature except for palmar hæmorrhage or direct wounds. In the former case the artery can easily be secured just above the wrist, in the latter case, by enlarging the original wound. Various stereotyped operations are described, but are more often seen in the examination-room or dead-house than in the operating theatre. It should be borne in mind that the artery curves inwards from the centre of the bend of the elbow to the radial side of the pisiform bone. The lower two-thirds of its course is indicated by a line drawn from the internal condyle of the humerus to the same spot below.

1. *At the Wrist.*—An incision about 1 inch in length is made directly upwards from the flexure of the wrist in the line of the vessel (Fig. 111, F). The deep fascia is opened, the tendon of the flexor carpi ulnaris drawn to the inner side, and the vessels are then seen, accompanied by the nerve which lies to the ulnar side of the artery.

2. *In the Middle of the Forearm*—An incision is made along a line drawn from the anterior edge of the tip of the inner condyle to the radial side of the pisiform bone (Fig. 111, G). The white line indicating the intermuscular septum between the flexor carpi ulnaris and flexor sublimis digitorum is then sought for and opened up; it is often very slightly marked, and may be difficult to distinguish. If the correct interspace has been opened, the surgeon is directed towards the ulna, and readily finds the vessels under cover of the

flexor carpi ulnaris, with the nerve lying a little way to the inner or ulnar side.

3. The upper limit of the ulnar artery can be reached through an oblique incision along the upper border of the pronator teres, thus opening up the antecubital fossa, and exposing the bifurcation of the brachial.

Radial Artery.—The line of the vessel extends from the middle of the bend of the elbow to the interspace at the wrist between the flexor carpi radialis and the supinator longus It then turns outwards, and may be felt beating in the space between the tendons of the extensor primi and extensor secundi internodii muscles

1. *At the Back of the Wrist* the vessel may be secured by opening up the above-mentioned intertendinous hollow, where the artery is found coursing onwards to the base of the first interosseous space The incision is placed obliquely between the tendons, extending from the back of the styloid process of the radius to the base of the first metacarpal bone.

2. *Above the Wrist* an incision is made in the line of the vessel (Fig. 111, E), which is found after division of the fascia between the supinator longus and flexor carpi radialis.

3. *In the Middle or Upper Third of the Forearm* an incision is made in the line of the vessel (Fig. 111, D), and the inner border of the supinator longus sought for and retracted The vessels are found under cover of this structure, with the radial nerve to the outer side, though separated by an interval above.

Ligature of the Abdominal Aorta has been undertaken in fourteen instances for severe primary or secondary hæmorrhage, or for diffuse inguinal or iliac aneurism, when no other method of treatment was practicable All these cases have proved fatal, in most instances from infection and secondary hæmorrhage.

The **Common Iliac Artery** extends for a distance of 2 inches from the bifurcation of the aorta opposite the left side of the body of the fourth lumbar vertebra to the front of the sacro-iliac synchondrosis. It may be reached through an incision made in the median line with its centre a little below the umbilicus The vessel is sought for and exposed by an incision through the posterior layer of the parietal peritoneum, and a ligature passed and tied The ureter which crosses the artery just above its bifurcation must be carefully avoided.

Collateral Circulation.—Blood reaches the *external iliac* and its branches by means of the anastomosis of the lumbar arteries *with* the circumflex iliac, and of the superior epigastric, lumbars, and intercostals *with* the superficial and deep epigastric. The *internal iliac* and its branches are supplied by the union of (*a*) the lumbar branches *with* the ilio-lumbar; (*b*) the middle sacral *with* the lateral sacral; (*c*) the retropubic anastomosis of the two obturator arteries; and (*d*) the communications of the pudic, hæmorrhoidal, and vesical trunks *with* those of the opposite side.

Ligature of the Internal Iliac Artery is occasionally performed for hæmorrhage from, or aneurism of, one of its branches, the gluteal being that most commonly affected. The trunk is a short one, at most $1\frac{1}{2}$ inches in length, and is best reached by opening the abdomen in the middle line below the umbilicus (Fig. 112, C), pushing aside the intestines, and searching for the bifurcation of the common iliac. The posterior layer of the peritoneum is then carefully incised, the ureter avoided, and an armed aneurism needle passed without wounding the vein.

The *Collateral Circulation* is the same as that given for the internal iliac division of the common iliac.

The **External Iliac Artery** is easily accessible in any part of its course, which measures from $3\frac{1}{2}$ to 4 inches in length; it has but few branches, and those situated low down Its position is indicated by the lower two-thirds of a line drawn from the bifurcation of the aorta to midway between the anterior superior spine and the symphysis pubis—*i e.*, to a point a little internal to the middle of Poupart's ligament.

Many suggestions as to the best means of reaching the artery have been made, and both trans- and extra-peritoneal methods have been adopted. It is so

readily secured, however, by the latter that it seems unnecessary to open the peritoneum. There are two chief forms of extraperitoneal operation.

Astley Cooper's Operation.—An incision is made parallel to the outer half of Poupart's ligament, commencing a little to the inner side of its centre, and ¾ inch above it, and extending upwards and outwards to about 1 inch internal to the anterior superior spine (Fig. 112, E). The external oblique aponeurosis is divided along this line, and the exposed lower margins of the internal oblique and transversalis muscles arching over the inguinal canal are drawn upwards by retractors. The transversalis fascia and loose subperitoneal fat are now opened with forceps and director, and the vessel is felt pulsating immediately under the finger. The epigastric and circumflex iliac arteries must not be damaged during this manipulation, since they are important factors in the collateral circulation. The needle is passed from within outwards, the ligature tied, and the divided muscular and aponeurotic structures united by buried sutures.

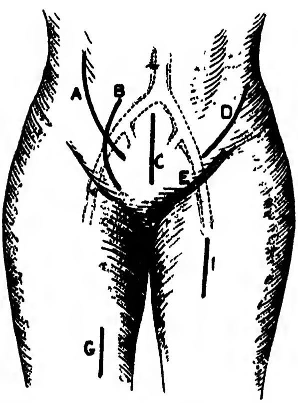


FIG. 112.—INCISIONS FOR OPERATIONS ON LOWER PART OF ABDOMEN AND UPPER PART OF THIGHS.

A, Mott's incision for retroperitoneal ligature of common iliac artery; B, Marcellin Duval's incision for the same; C, incision for transperitoneal ligature of internal iliac artery; D, Abernethy's modified operation for ligature of external iliac; E, Astley Cooper's incision for same; G, ligature of femoral artery in Hunter's canal; I, ligature of femoral artery at apex of Scarpa's triangle.

Abernethy's Modified Operation is more commonly utilized. The incision, about 4 inches in length, extends from a point 1½ inches within and above the anterior superior iliac spine to just external to, and ½ inch above, the middle of Poupart's ligament (Fig. 112, D). Through this the aponeurosis of the external oblique is divided along the course of its fibres, as also the internal oblique and transversalis. The transversalis fascia is now carefully incised; it varies considerably in thickness, being sometimes well developed, but is occasionally so attenuated as to be scarcely recognizable. The fingers are now introduced into the wound, and the peritoneum and its contents stripped from the iliac fossa, and drawn inwards and forwards, where they are kept out of the way by a broad spatula. In the space thus opened up one can see the iliacus muscle covered by its fascia, and to its inner side the rounded outline of the psoas. The vessel lies to the inner border of this, and can usually be readily found, enveloped in a fascial sheath, with the genito-crural nerve coursing over it, and perhaps some lymphatic glands upon it. The artery is separated from the vein which lies to the inner side, and the needle passed from within outwards.

Collateral Circulation.—*Anterior set:* Superior epigastric of internal mammary, lumbar, and lower intercostals *with* superficial and deep epigastric in sheath of rectus.

Posterior set: Gluteal and sciatic *with* internal and external circumflex and first perforating of profunda at back of great trochanter (crucial anastomosis).

External set: Ilio-lumbar and gluteal *with* deep and superficial circumflex iliac and ascending branch of external circumflex.

Internal set: Obturator *with* internal circumflex; and terminal divisions of internal pudic *with* superficial and deep external pudic.

The **Common Femoral Artery** is but rarely ligatured, except as a preliminary measure in amputation at the hip-joint, since the number of branches arising from it is likely to interfere with its sound occlusion, and the collateral circula-

tion is better after ligature of the external iliac. It may be reached by a vertical incision over the line of the vessel, extending both a little above and below Poupart's ligament. The superficial lymphatics and veins must be carefully avoided, the fascia lata divided, the sheath exposed and opened, and the ligature passed from the inner side.

Collateral Circulation.—Internal set: Obturator *with* internal circumflex, and internal pudic *with* external pudic.

External set: Circumflex iliac *with* ascending branch of external circumflex.

Posterior set: Gluteal and sciatic *with* internal and external circumflex, and first perforating; comes nervi ischiadici *with* perforating of the profunda and muscular of popliteal.

The **Superficial Femoral Artery** is indicated by a line drawn from midway between the anterior superior spine and the symphysis pubis to the tuberosity of the internal condyle, the limb being flexed, abducted, and everted. It may be secured at 'the site of election'—*i.e.*, at the apex of Scarpa's triangle—or in Hunter's canal.

Ligature at the Apex of Scarpa's Triangle.—A 4-inch incision is made in the line of the artery, the centre being about 4 inches (or a hand's breadth) below Poupart's ligament (Fig. 112, I). The integument and fasciæ are divided, the inner border of the sartorius exposed, and the sheath found immediately behind it, the muscle being drawn slightly outwards; the middle cutaneous nerve is perhaps brought into view. The vein is placed behind the artery at this level.

Collateral Circulation.—External circumflex *with* lower muscular of femoral, anastomotica magna, and superior articular of popliteal.

Profunda femoris by its perforating and terminal branches *with* the muscular and articular branches of femoral and popliteal.

Ligature in Hunter's Canal.—An incision 4 inches in length is made along the line of the artery in the middle of the thigh (Fig. 112, G). The sartorius is exposed by division of the fascia lata, its fibres running downwards and inwards; its outer border should be defined, and the muscle retracted inwards. The aponeurotic covering of Hunter's canal is now in view, stretching between the adductor longus and vastus internus; it is incised, and the sheath of the vessel found below it, with the nerve to the vastus internus lying to its outer side, the long saphenous nerve crossing it from without inwards, and the vein passing behind it, to become external lower down.

Collateral Circulation is maintained through the profunda and its branches.

The **Popliteal Artery** may be tied either just after it has passed through the adductor opening, or in the depths of the popliteal space, but preferably in the former situation. Neither operation is often required.

To tie the *upper part*, the limb is fully abducted and everted so as to enable the adductor tubercle and tendon of the adductor magnus to be clearly defined. An incision, 4 inches in length, is then made from the tubercle upwards (Fig. 113, A), and the tendon exposed. The internal saphenous vein and nerve may be seen, but are drawn backwards by means of a broad retractor, together with the sartorius, gracilis, and semi-membranosus. If possible, the branch of the anastomotica magna which courses along the tendon should be spared. The fascial space behind is now opened up, and the artery found surrounded by a good deal of loose connective tissue. The vein is usually seen on the outer side, and is here very thick and dense, so that in the dead subject it can be readily mistaken for the artery.

The *lower part* is tied through an incision in the middle line of the popliteal space, dividing the deep fascia and drawing out of the way the heads of the gastrocnemius muscle and the internal popliteal nerve. The vein is superficial to the artery, and is found by following the short saphenous trunk.

Collateral Circulation is maintained by the anastomoses around the knee-joint.

The **Posterior Tibial Artery** but seldom requires to be ligatured except for hæmorrhage, or on the face of amputation stumps; hence the operations described below are rarely seen away from the dead-house. The line of the

vessel is indicated by one drawn from the centre of the popliteal space to a point a finger's breadth behind the internal malleolus.

1. *In the Middle of the Calf.*—The leg is placed on its outer side and flexed, and an incision 4 inches long is made a finger's breadth behind the inner border of the tibia (Fig. 113, B), dividing the skin and subcutaneous tissues, the long saphenous vein and nerve being drawn aside if necessary. The tibial origin of the soleus is thus exposed, and incised directly towards the tibia, until the fibrous aponeurosis on its deeper surface is met with. This having been cut through, the muscle is drawn backwards with the retractor, and the vessels, ensheathed in a deep layer of fascia, are seen lying on the tibialis posticus, and with the posterior tibial nerve to the outer side.

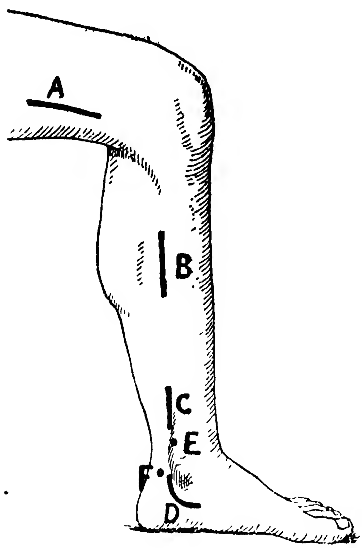


FIG. 113.—INCISIONS FOR LIGATURE OF THE UPPER PART OF THE POPLITEAL (A), AND OF THE POSTERIOR TIBIAL ARTERIES (B, C, and D).

E, Site for Introduction of knife in Tenotomy of Tibialis Posticus; F, Ditto for Tendo Achillis.

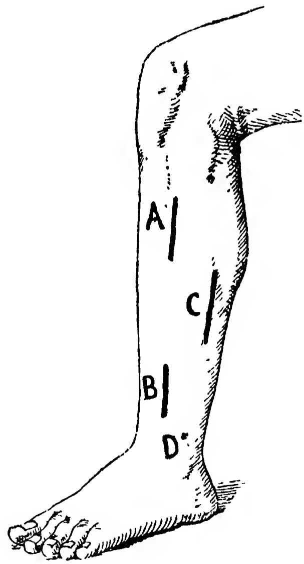


FIG. 114.—INCISIONS FOR LIGATURE OF ANTERIOR TIBIAL (A AND B) AND PERONEAL (C) ARTERIES. D, SITE FOR INTRODUCTION OF KNIFE IN TENOTOMY OF PERONEI.

2. *In the Lower Third of the Leg*—An incision is made midway between the tendo Achillis and inner border of the tibia (Fig. 113, C). The skin and fasciæ, including the upper part of the internal annular ligament, are divided, and the vessels seen lying on the flexor longus digitorum, with the nerve behind and to the outer side.

3. *Behind the Malleolus.*—An incision is made about a finger's breadth from the malleolus, curving round its lower border (Fig. 113, D). The deep fascia (or, as it is here termed, the internal annular ligament) is divided over the vessels between the tendons of the flexor longus digitorum and flexor proprius hallucis, and the artery is then readily cleared and ligatured. The sheaths of the tendons should not be opened.

The **Anterior Tibial Artery** is found along a line stretching from a point midway between the outer tuberosity of the tibia and the head of the fibula above

to the central point between the two malleoli below. It may be tied in three situations.

1. *In the Upper Third of the Leg.*—An incision is made exactly in the line of the artery (Fig. 114, A), and the deep fascia incised. The intermuscular space between the tibialis anticus and the extensor communis digitorum is opened. The vessel lies between these muscles upon the interosseous membrane, the anterior tibial nerve being to the outer side.

2. *In the Middle of the Leg* (Fig. 114, B).—The same intermuscular space is opened, being indicated here by a definite white line, due to a slight subfascial deposit of fat. The vessels lie between the tibialis anticus and the deeply-placed extensor proprius hallucis, the nerve usually lying on the artery and needing to be drawn aside.

3. *In the Lower Third of the Leg.*—An incision is made in the line of the artery, reaching upwards for 2 inches from a point just above the ankle (Fig. 115, A). The deep fascia and upper part of the annular ligament are divided, and the vessel is found between the tendons of the tibialis anticus and of the extensor proprius hallucis, the nerve lying to the outer side.

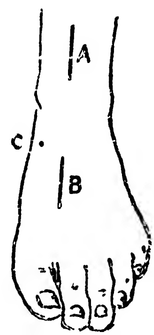


FIG. 115.—INCISIONS FOR LIGATURE OF LOWER PART OF ANTERIOR TIBIAL (A) AND DORSALIS PEDIS (B) ARTERIES. C, SITE FOR PERFORMING TENOTOMY OF TIBIALIS ANTICUS.

The **Dorsalis Pedis Artery** extends from the centre of the line between the two malleoli to the interval between the bases of the first two metatarsal bones. An incision is made in this direction (Fig. 115, B), the deep fascia opened, and the artery found lying between the extensor proprius hallucis, which has now crossed and is internal to the vessel, and the innermost slip of the extensor brevis digitorum. It is not always easy to find, and for practical purposes the best plan would be to divide the vessel by an incision extending to the bones, and then pick up and tie the bleeding ends.

The **Peroneal Artery** can be reached through an incision along the posterior border of the centre of the fibula, the leg being laid on its inner side (Fig. 114, C). The outer edge of the soleus is defined and drawn inwards, the lower fibres of attachment to the fibula being divided if necessary. The flexor longus hallucis is thereby exposed, and incised in such a manner as to allow the surgeon to reach the postero-internal border of the fibula; the artery is then readily found lying in an osseo-aponeurotic canal.

CHAPTER XIV.

AFFECTIONS OF THE VEINS—ANGIOMATA.

Venous Thrombosis.

By **Thrombosis** is meant intravascular coagulation in any part of the circulatory system. Normally, the blood remains in a fluid condition, owing to some inter-action between it and the vessel walls. Any factor producing a disturbance of this normal equilibrium may determine thrombosis, and any part of the vascular tract may be affected by it, whether the heart, arteries, veins, or capillaries; but it is in the veins that it occurs most frequently.

Causes.—(1) *Changes in the vessel walls*, as a result of which the integrity of the endothelium is disturbed—*e.g.*, injury (either division, rupture, puncture, compression, or contusion), inflammation or degeneration (as in varicose veins).

(2) *Changes in the constitution of the blood* whereby its coagulability is increased. In clinical work this is brought about most frequently by infective conditions, which lead to an excess of toxins in the blood. Hæmorrhage up to half of the whole amount in the body also increases its coagulability, but excess of leucocytes, as in leukæmia, has the opposite effect.

(3) *Diminished rate of the blood-stream* predisposes to thrombosis if some other condition is present to determine it. Lister showed years ago that blood can remain fluid for a long time if confined in a tube formed of a suitable length of healthy vein wall; but when either of the preceding factors is present, a retardation of the blood-stream materially assists in causing coagulation. Thus, when a vein is pressed upon by a tumour, the obstruction to the blood-flow produces a clot at the spot where the nutrition of the wall is interfered with. After fevers, such as typhoid, where the character of the blood is somewhat altered and the action of the heart weakened by changes in the myocardium, the defective *vis a tergo* causes a retardation of the flow in the veins, and coagulation is probably determined by some slight injury or pressure which is not noticed by the patient.

The **Character** of the clot varies with its rate of formation. If developed slowly, the so-called white thrombus is met with, consisting merely of layers of fibrin, similar to that formed in an aneurism. If the process is more rapid, a certain number of red corpuscles are entangled in the meshes of the clot: sudden coagula-

tion produces the ordinary red thrombus, which at first is not adherent to the wall, but becomes so later on, especially at its base.

The **Effects** of thrombosis may be considered under the following headings: local, distal, and proximal.

Locally.—(*a*) The clot may be organized into connective tissue, a fibrous cord replacing the vessel in the same way as was described for arterial thrombosis (p. 327). Three weeks is about the shortest period to allow for the safe fixation of the clot within the vessel. (*b*) The lumen of the vein may be re-established by the fixation of the thrombus to one side of the vein wall, or by canalization of the clot or of the fibrous cicatrix replacing it, owing to the dilatation

FIG. 116.—VARICOSE CONDITION OF THE VEINS OF THE ABDOMINAL WALL SECONDARY TO PERMANENT OBSTRUCTION OF THE INFERIOR VENA CAVA.

of the vessels contained within. (*c*) The clot may shrink or become loosened in an ampulla of a varicose vein, forming a fibrinous mass, which is subsequently infiltrated with calcareous particles, constituting a vein-stone or *Phlebolith*. (*d*) Suppuration may occur in and around the clot as a result of its bacterial content.

A localized abscess may follow, or the pus may spread widely along the course of the vein (periphlebitis). Pyæmia is likely to develop, but this may be hindered for a time by the formation of a cap of healthy red clot, which covers over and protects the infected portion.

Distally.—The area drained by the affected vein becomes congested and œdematous, if sufficient collateral circulation does not

exist, unless it is kept well raised and supported. In favourable cases collateral circulation is soon established by the opening up of other venous channels, which after a time may become varicose, and, if situated superficially, are often very obvious. Thus, if the external iliac vein is occluded above Poupart's ligament, a greatly increased amount of blood will be carried by the internal saphena vein, and some of it will find its way *via* the superficial epigastric and pudic veins across the middle line to the internal saphena of the opposite side. These branches become dilated and varicose, and the inverted Λ of the two superficial epigastric veins is very characteristic. If the inferior vena cava is obstructed, the mammary and epigastric veins become dilated and tortuous, the latter standing out prominently on the anterior abdominal wall (Fig. 116).

Proximally, the process may gradually extend upwards, and finally involve larger and more important trunks than that in which it originated. Moreover, a portion of a thrombus may be detached as an *Embolus* (Fig. 117, B). If the clot is undergoing molecular disintegration, and only minute portions are set free, they are filtered off by the lungs or kidneys, and no symptoms need be caused. If, however, a large portion is detached, urgent dyspnœa and even death occur from obstruction to the pulmonary vessels and subsequent arrest of the circulation. If the clot becomes infected, and fragments conveying organisms are carried into the circulation, pyæmia is the result, preceded, however, in the portal area by pylephlebitis—*i.e.*, suppurative phlebitis of the portal trunk in the liver.

Femoral thrombosis is of considerable interest to the surgeon, as it is not uncommon after operations on the pelvic viscera, *e.g.* the uterus or prostate, and is frequently seen as a complication of a suppurative appendicitis, the thrombosis spreading from the divided veins in the parietal incision, or *via* venous communications in the meso-appendix, or possibly as a result of the direct involvement of the right iliac vein in the inflammatory trouble. The condition is not an unfrequent complication of parturition, and is then due to extension of the clotting from the uterine veins (*phlegmasia alba dolens*). It may develop in the course of typhoid fever, or follow any condition or operation which depresses the patient's vitality and keeps him bedridden with the legs quiet.

It is most frequently seen in the left leg, and according to its varied cause the clotting may start in the pelvic veins and spread upwards to the common iliac vein; or it may commence in branches of the external iliac, and so progress to the main trunk; or the femoral vein usually about its junction with the saphena may be first involved. In all cases the thrombosis is likely to spread down the femoral vein for some distance, and up the common iliac trunk, sometimes involving the bifurcation of the vena cava, and so extending to the opposite side of the body. It is difficult to give quite a satisfactory explanation of the more frequent involvement of the left side of the body, but probably it is due to unnecessary

limitations of the movements of the legs, together with anatomical differences in the arrangements of the valves in the veins to the detriment of the circulation on the left side.

The **Clinical Signs** and **Treatment** are as for Phlebitis (p. 385).

Embolism.

An Embolus is the term applied to any foreign body which travels for a greater or less distance in the bloodvessels until it becomes lodged within them and causes obstruction. There are four main varieties of embolus: (*a*) **Simple Emboli**—*e.g.*, blood-clot, granulations or fibrinous vegetations from the cardiac valves after acute endocarditis, atheromatous plates, air-bubbles, fat globules, etc. (*b*) **Infective Emboli** consist of either zoogloea masses of bacteria or disintegrated portions of blood-clot carrying micro-organisms, and are the cause of the abscesses in pyæmia. (*c*) **Malignant Emboli** are formed by portions of some malignant growth, from which the various secondary deposits originate; these are met with more frequently in the sarcomata than in the carcinomata. (*d*) **Parasitic Emboli** also occur, such as the ova and scolices of the *Tænia echinococcus* and the *Filaria sanguinis hominis*.

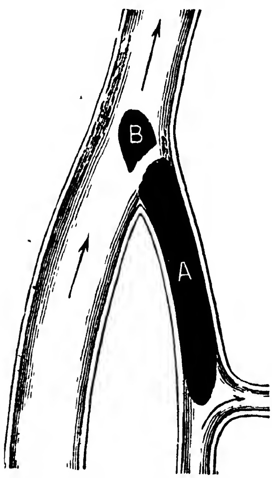


FIG. 117.—THROMBUS AND EMBOLUS. (KEEN AND WHITE.)

A, Thrombus *in situ*; B, embolus detached from the same.

Emboli may be detached from the heart, veins, or arteries, although necessarily they are never arrested in a systemic vein, but only in the arteries or portal vein. They are of all sizes, and the character of the resulting symptoms depends much on this. A large embolus started in a peripheral vein lodges in one of the branches of the pulmonary artery, and may cause instant death; a smaller one is arrested in one of the smaller arteries of the lung and may do but little harm, whilst minute ones may possibly pass through the pulmonary capillaries to the left side of the heart, and subsequently become impacted in the systemic vessels.

Effects of an Embolus. The **Local** effects of the lodgment of a simple embolus consist, firstly, in the deposit of fibrin upon it, rendering the obstruction complete, if this is not already the case; organization of the thrombus usually follows, although occasionally it may disintegrate and disappear. The local effects of infective, malignant, and parasitic emboli are dealt with elsewhere.

The **Distal** effects of embolic obstruction depend entirely on the relation of the vessel blocked to the surrounding circulation.

(1) Should the embolus be lodged in an artery which gives off anastomotic branches below the point of obstruction, or if the capillary anastomosis is abundant, a **transient anæmia** is all that occurs in most cases. If the artery is small, or goes to unimportant structures, no symptoms need arise from this; but if the vessel is large, or supplies delicate and important tissues, serious results may follow even a temporary arrest of the circulation; thus, embolus of the central artery of the retina always causes permanent blindness, although the retina still lives.

(2) Should the embolus block what is called a 'terminal artery' (*i.e.*, one with no anastomosis between the embolus and the terminal capillaries), or a vessel with insufficient collateral circulation, the obstruction will lead to **death** of, at any rate, a portion of the anæmic region—*e.g.*, gangrene in a limb, or

white or yellow softening in the brain. In an organ such as the kidney or spleen, the result of embolic obstruction to one of the terminal arteries is the development of an **infarct**; *i.e.*, a wedge-shaped area of tissue with the blocked artery at its apex becomes devitalized, and in consequence looks white and feels firmer than the surrounding parts. The tissues cannot be properly stained for microscopic purposes. Sometimes the anæmic area becomes engorged with blood to such an extent as to lead to extravasation, and a firm, solid patch of a dark red colour results, known as a **hæmorrhagic infarct.** Whatever its appearance, the infarct is subsequently invaded by granulation tissue developed from the surrounding healthy parts, and this finally results in the formation of a depressed cicatrix containing, perhaps, a few hæmatoidin crystals. The conditions necessary for the production of an infarct are met with in the lungs, spleen, kidney, and brain; in the liver the anastomosis is generally too free to allow of its formation, although it has been known to occur.

Effects of the Lodgment of Emboli in Various Organs.—In the **Brain,** the middle cerebral artery is most commonly blocked, resulting in immediate hemiplegia, which may be almost entirely recovered from, but commonly leaves some impairment of function. In children the symptoms are less marked, but aneurism of the affected vessel occasionally follows. In the **Central Artery of the Retina,** sudden, total, and irremediable blindness is produced; the branches of the vessel are seen to be almost empty, the retina becomes œdematous, the macula alone retaining its normal colour, appearing as a cherry-red spot, contrasting markedly with the pallid œdematous tissues around. In the **Lung,** fatal results supervene from obstruction to the main pulmonary artery; attempts have been made to save life by opening the chest, incising the pulmonary artery, and scraping or pulling out the clot, and subsequently suturing the vessel. It is obvious that such a proceeding is not often likely to be feasible. If one of the smaller branches is blocked, a certain amount of pain and dyspnœa is produced, followed by the formation of an infarct, as indicated by blood-stained sputum, dulness, bronchial breathing, and bronchophony. In the **Liver,** an embolus of the hepatic artery causes sudden hypochondriac pain, and perhaps a temporary glycosuria. The portal vein and its branches are not unfrequently obstructed by emboli, which, being usually of an infected nature, give rise to pyæmic symptoms (pylephlebitis). In the **Spleen,** a sudden pain in the left hypochondrium is experienced, the organ becomes enlarged, and a considerable rise of temperature may follow. In the **Kidney,** sudden pain in the loin and a temporary hæmaturia constitute the main symptoms. In the **Intestine,** localized ulceration or extensive gangrene is likely to follow, according to the size of the vessel obstructed. In the **Limbs,** the emboli usually lodge at the bifurcations of main vessels, often saddling across the fork, and blocking both branches. Sudden pain is felt at the spot, shooting downwards, and either recovery or gangrene ensues (p. 117).

Phlebitis.

Phlebitis, or inflammation of the vein wall. arises from a variety of causes, and is not uncommon in surgical practice. The following forms are described:

1. **Simple Phlebitis,** in which a more or less *localized* inflammation of the wall of a vein is attended by thrombosis, which extends for a variable distance up and down the vessel. (*a*) It may arise from *injury*, either subcutaneous or open, or from the continued pressure and irritation of a tumour or aneurism; (*b*) it may be gouty or rheumatic in nature, attacking the larger veins of the lower extremity, or vessels which have been long subject to varix. (*c*) It may follow primary thrombosis, either in the main trunk or in a varicose peri-

pheral vein; or (*d*) it may be induced by inflammation of the tissues around the vein (*periphlebitis*), usually of bacterial origin. In the last case the bacteria gradually spread through the vein wall, and finally invade the clot. 22·7·48·

2. **Infective Phlebitis** is a much more serious condition, inasmuch as the thrombus resulting therefrom always contains micro-organisms, and the disease is often of the *spreading* type. It arises (*a*) in traumatic cases where asepsis has not been maintained, the organisms invading the clot which lies in the open mouth of the vein; or (*b*) as a result of infective periphlebitis in wounds, or in infective inflammation of bones, such as when a suppurative mastoiditis leads to thrombosis of the lateral sinus; and (*c*) by auto-infection of the clot present in simple phlebitis, as, *e.g.*, in varicose veins.

Morbid Anatomy.—The walls of the vein are congested and thickened, and the endothelial lining is hypertrophied. The thrombus, if aseptic, early becomes adherent to the vein wall and organized, or is absorbed; if infected, it becomes soft and pultaceous, resembling dirty-looking pus; a localized abscess may form, and the suppuration may extend for some distance along and around the vein.

The **Symptoms** of inflammation of a **superficial** vein are sufficiently obvious. The vessel becomes swollen, hard, and painful, with localized enlargements or knobs corresponding to the valves or to the pouches in varicose veins. The skin over them is dusky and congested, and there may be some œdema of the region from which the blood flowing in the vein is gathered; this, however, rarely amounts to much, since the collateral circulation is always abundant. The temperature is usually raised, and the patient feels ill. If suppuration occurs, the signs of a localized abscess are noted, and perhaps pyæmic manifestations supervene.

When the **deeper** veins are involved, it may be impossible to detect them on palpation, although a blocked common femoral can usually be felt; but acute deeply-seated pain over the vein and well-marked fever are characteristic evidences of what has occurred. Œdema of a more or less solid character develops, although if the limb is maintained in the horizontal position throughout the attack this need not occur. Obliteration of the vessel and any of the local, distal, or general processes detailed as characteristic of thrombosis (p. 381) may result.

The onset of an **infective periphlebitis** is marked by fever and perhaps rigors, whilst the local signs are due to rapid extension of a suppurative inflammation along the vein and its branches, so that a large tract of tissue is very quickly invaded, and diffuse suppuration follows. The presence of pyæmia is indicated by a repetition of rigors, and the development of secondary abscesses.

Treatment.—In the **simple** variety the limb is kept at rest to limit inflammation and prevent the detachment of emboli, and also elevated to assist venous return. Locally, belladonna fomentations may be applied, or the parts may be painted with antiphlogistine or with glycerine and extract of belladonna; the limb is then

lightly bandaged over a thick layer of cotton-wool. The intravenous injection of 5 to 10 ounces of a 0·5 per cent. solution of sodium citrate in normal salt solution appears to cause a rapid cessation of pain and tenderness, whilst it stays the spread of the trouble and hastens the disappearance of the œdema. The injection is sometimes followed by a rigor, but that does not seem to do any harm. The patient should be kept on an unstimulating though nutritious diet, and the general health attended to. When every sign of inflammation has subsided, and sufficient time has been allowed for the absorption or organization of the clot (three weeks as an absolute minimum—six weeks for choice), massage may be commenced, to assist in the removal of œdema and local thickening, and an elastic bandage is usually serviceable in restoring the circulation.

Infective phlebitis is treated in a similar fashion until suppuration occurs, and then the pus must be evacuated, and it is sometimes remarkable to note how quickly the process quiets down when once drainage is effected. A **spreading periphlebitis** will often involve an extensive area, but the process must be followed up ruthlessly by the knife and the parts laid open. The wounds thus made should be lightly packed and allowed to granulate; at the same time the limb is raised, and kept absolutely quiet. Should pyæmic phenomena develop, it may be necessary to place a ligature between the disintegrating clot and the heart, and to scrape or wash away the infective material; thus, in thrombosis of the lateral sinus, following suppuration in the middle ear, the internal jugular vein should be ligatured, the lateral sinus opened, and the clot removed. Of course, such treatment is only feasible in cases where a single trunk is affected. When the process involves the veins of a limb, and cannot be stopped by either of these plans of treatment, the question of amputation may have to be raised.

Varicose Veins, or Varix.

A vein is said to be in a condition of varix when it has become dilated, permanently lengthened, and more or less tortuous. The superficial veins of the leg, especially the internal and external saphena, are those most commonly affected; the spermatic veins are often in a similar condition, constituting what is known as a varicocele, whilst piles are primarily due to varicosity of the hæmorrhoidal plexus. We shall here only deal with the first of these three manifestations.

Causes.—Varix is possibly due to some inherited weakness of the venous wall, or irregularity in the arrangement of the valves, or peculiarity in the lower fascial border of the saphenous opening, though these may produce no ill effect until some exciting cause comes into action. The condition sometimes appears quite early in life, and often involves the same vein in different members of a family.

The condition also results from persistent distension of a vein, as by wearing tight garters, or by the pressure of a pregnant or displaced uterus, or of a pelvic tumour; or from prolonged standing, which may cause tension of the deep fascia of the thigh, and this may lead to constriction of the veins at the openings through which they pass to deeper parts—*e.g.*, the saphenous opening with its sharply defined falciform border. Valvular incompetence from the giving way of valves in the upper part of the saphena as a result of severe exertions—*e.g.*, in athletics—may lead to varix, as the effect of the gradually increasing weight of the superincumbent column of blood. Occlusion of the deeper veins—*e.g.*, of the common femoral or vena cava (p. 382)—leads to distension and varix of the superficial; thus thrombosis of the venæ comites of the posterior tibial, due to muscular strains, may be followed by varix of the internal saphena or some of its branches below the knee. An abnormal communication between an artery and vein also results in varix from the inability of the latter to withstand arterial blood-pressure (*vide* Aneurismal Varix, p. 344). The tendency to varix increases with age till the middle period of life is reached, and is favoured by relaxation of the system resulting from sedentary habits.

Morbid Anatomy.—To the naked eye a varicose vein in an early stage appears thickened, distended, and tortuous; the walls are so thick that the vein when cut across does not collapse, but presents a gaping mouth, like an artery; the valves atrophy, and are functionally useless. After a time the walls become further stretched and irregularly expanded, forming here and there cyst-like dilatations, which are very obvious under the attenuated skin, to which they are often adherent. Microscopically, the change consists in a transformation of the normal structures of the vein wall into fibro-cicatricial tissue. The tunica media is mainly affected, most of the muscular fibres disappearing, whilst the tunica intima is but little changed, and the adventitia thickened. In the pouches the middle coat is atrophied, and, indeed, is often completely absent.

Clinical History.—The enlarged veins are seen ramifying under the skin with a more or less tortuous and serpentine course (Fig. 118), and they often feel thickened. One or more veins may be affected, and the tortuosity may be at parts so marked as to constitute large clusters of dilated vessels, which look bluish under the thin and stretched integument. In other cases a single vein is enlarged, and stands out prominently under the skin; or perhaps one or more cyst-like pouches develop in connection with these (Fig. 119). The upper end of the internal saphena is sometimes dilated so as to form a large pouch, in which a marked thrill is felt when the patient coughs, thereby simulating a femoral hernia. In other cases, although this portion of the vein is not dilated, yet its valves are incompetent, and the thrill produced by coughing can be felt even below the knee if that portion of the vein is dilated.

The **Effects** of varicose veins are very varied. The limb often feels heavy and tired; forcible exertion may cause a sensation of tension,

and after standing or exercise there is usually some œdema of the ankle. The capillaries in the papillæ often become dilated, appearing as minute reddish puncta, which subsequently run together and form brownish patches of pigmentation. Eczema is induced by the irritation of rough and coarse trousers or dirt, often terminating in actual ulceration. Any lesion, such as a scratch or abrasion, instead of healing readily under a scab, tends to spread and form an ulcer. Injury to the vein may lead to thrombosis and subsequent cure, but coagulation sometimes occurs spontaneously in cysts or acute kinks, especially in gouty subjects. The clot may subsequently shrink and

FIG. 118.—VARIX OF INTERNAL SAPHENA VEINS.

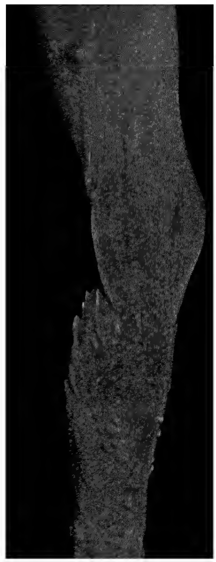


FIG. 119.—VARIX OF LEFT INTERNAL SAPHENA, SHOWING AN AMPULLA ABOVE.

form a small fibrinous or calcareous mass, known as a 'phlebolith,' but sometimes the thrombosis spreads into deeper or larger veins, and then fragments of clot may be detached as emboli. Occasionally the dilated pouch of a varicose vein gives way, and an alarming rush of blood results; the same may follow the extension of ulceration through the vein wall. The blood under these circumstances is derived, not only from the lower, but also from the upper end; and if the valves have become incompetent, a column of blood extending from the right auricle is thus tapped near its lower end, and, unless prompt precautions are taken, the patient's life may be lost.

The **Treatment** of varicose veins may be described as palliative or radical.

Palliative Treatment consists in removing any source of obstruction in the shape of tight garters, in limiting the amount of standing, in moderate massage, together with the application of either an elastic stocking or an indiarubber bandage. The bowels should be regulated, and the general health attended to. Eczema may be treated by the application of soothing and drying ointments, *e.g.* ung. zinci benzoatis; or if the skin is chronically infiltrated and thickened, by the use of weak tarry applications, *e.g.* ol. Rusci (1 part to 4 of vaseline), or of ichthyol (5 or 10 per cent. in vaseline). Varicose ulcers are suitably treated (p. 106), but repair is often delayed till the veins have been dealt with by operation.

Operative Treatment may be directed either to the obliteration of the distended veins or to their complete removal.

1. The *obliteration* of varicose veins without a cutting operation was the aim of surgeons in pre-antiseptic days when the fear of pyæmia was ever present. Of late a similar object has been sought by modern methods so as to avoid the discomfort, expense, and manifold objections to extensive operations which are not always successful. It has been found that the injection into the lumen of various more or less irritating fluids, whose absorption into the blood-stream is not harmful, is followed by a plastic thrombophlebitis, limited in extent to the neighbourhood of the injection, and without pain or the necessity for prolonged rest, and thereby obliteration is secured. The thrombi are very adherent, and thus there appears to be no risk of embolus. A solution of salicylate of soda, 30 or 40 per cent., is very suitable, but solutions of quinine or biniodide of mercury have also been employed. The latest solution to be advocated is sodium morrhuate, it has no toxicity, and amounts up to 10 or 12 c.c. of a 10 per cent. solution have been given at one time. In most cases ½ to 1 c.c. is the correct dose for each injection. A 3 c.c. special syringe should be used (Fig. 120), fitted with a needle 1 inch in length with a short bevel. The skin over the site is cleansed with ether, and the needle introduced into the lowest portion of the varicose vein. That the needle is actually in the vein is verified by drawing out the piston and observing blood flow back into the enlarged neck of the syringe (Fig. 120), after which 2 or 3 c.c. of the solution are injected, according to the size of the vein. The greatest care must be

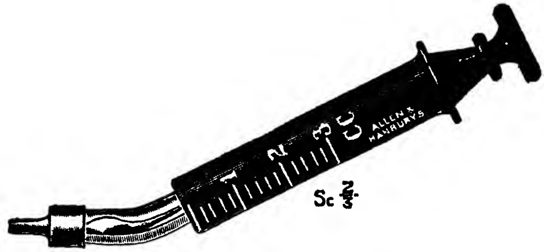


FIG. 120.—SYRINGE USED FOR INJECTING VARICOSE VEINS.

taken to prevent any escape of the fluid into the tissues, as necrosis may be thereby determined. A small dressing is applied, and the patient is allowed to return to his work. In a day or two the vein wall is sensitive and a little thickened, but obliteration usually follows without trouble. Possibly 3 or 4 inches of the vein are occluded as the result of a single injection. This procedure may be repeated as often as is considered necessary in different portions of the limb. It is probably not wise to adopt such a method for the larger trunks, *e.g.* the internal saphena in the upper part of the thigh, when there is a marked thrill on coughing.

2. *Excision* of varicose veins has been much employed during the past forty years, with results which have been excellent in certain patients, but very unsatisfactory in others. The selection of suitable cases is all-important, but is not an easy matter. Where the condition is due to thrombosis of deep veins, operation always does more harm than good. When the cause is still operative and cannot be removed, it is useless to deal with the result. When the condition is very widely spread and an abundance of comparatively small distended veins exists, interference is undesirable. The most suitable conditions for operation are: for the removal of thin-wall pouches liable to burst; for large bunches of dilated veins; and for conditions due to valvular incompetence, as marked by the presence of a decided thrill on coughing.

The scope of the operation varies with the actual conditions present. 31.7.40

(1) Whenever there is a definite thrill to be felt on coughing, either over the upper end of the internal saphena vein, or still more in its branches at a lower level, *Trendelenburg's operation* should be undertaken. As originally designed, this consisted in dividing the vein and removing a segment of it close to the saphenous opening, so as to break the continuity of the column of blood. This, however, sometimes failed in its object, owing to the presence of important branches which entered the vein above the site of ligature, and therefore it is better to include the whole pouch in the scope of the excision, securing by distal ligature all the branches entering it. The communication with the deep femoral vein must be very securely tied, as considerable strain will be thrown on it during post-anæsthetic vomiting.

(2) The excision of veins at a lower level must be governed by the actual character of the particular case. Sometimes the veins are grouped in large bunches, the whole of which can be excised; sometimes the vein throughout its whole course is tortuous and dilated, and to leave any portion would mean troublesome thrombosis; at other times the dilated veins are scattered here and there, with perhaps an obvious ampulla or pouch, and then removal of portions will suffice. To cope with these varying conditions, the following operative measures are available: (*a*) Small portions may be removed at several different levels. The skin over the vein is incised, and the vessel cleared. As much as possible is

drawn up into the wound and a ligature applied at each end, the intervening portion being cut away; possibly 2½ inches of vein may be taken away through a 1-inch incision. The wound is sutured without drainage and dressed. (*b*) Some surgeons secure the main vein at different levels, and pull out the intervening portion by ordinary traction, or by threading it on a probe, passing the latter down the vein to the second wound, and drawing it out together with the vein—a simple matter where the vein is dilated and not tortuous, but otherwise scarcely feasible. (*c*) Extensive excision of the veins through long incisions, involving almost the whole length of the limb, have also been practised, and in suitable cases with excellent results. By this means not only is the main vein secured, but also lateral and deep communications are obliterated, and a much more effective cure is established. The chief objection is the severity of the operation, but with modern aseptic methods an incision extending the whole length of the limb should heal just as quickly and effectively as one 3 inches long. The results of considerable experience have demonstrated the value of such proceedings in suitable cases, the patients subsequently being able to walk about with complete freedom from pain or discomfort.

(3) In milder cases, where it is considered that the falciform border is the cause of the saphena varix, it may be sufficient to divide the fascia behind the vein and draw the two segments aside.

Inflamed Varicose Veins are not unfrequent, and may result in a natural cure of the condition. The symptoms are those of a superficial phlebitis, and the treatment indicated for that condition should be followed. In cases where there is much pain it may be justifiable to excise the thrombosed vessels, taking the precaution first to secure by ligature the vein above the clot, so as to prevent any risk of embolic detachment. Operation of a similar type is also required when thrombosis is gradually spreading upwards, and threatening to affect the deep trunks—*e.g.*, in the neighbourhood of the saphenous opening; or when portions of clot are being detached as emboli, giving rise to pulmonary symptoms.

Hæmorrhage from a Ruptured Vein needs prompt and decisive treatment. The bleeding spot should be commanded by digital compression, and the patient laid on the back with the limb elevated, until either a pad of antiseptic dressing can be applied to the wound or a handkerchief or bandage secured over it.

Venesection has largely fallen into disuse of late years, but is still occasionally employed with benefit in the following conditions: (*a*) When a patient is becoming cyanosed, and asphyxia is threatening as a result of pulmonary engorgement from mitral incompetence; (*b*) when some accident involving the chest wall and lungs diminishes the blood-aërating surface so that it cannot deal with the blood reaching it through the right side of the heart, which hence becomes

enormously distended, and threatens to stop in a condition of diastole; or (*c*) where inflammation of the brain is pending, and the pulse is hard and full; or (*d*) in a few inflammatory states in strong, full-blooded individuals where the pulse-tension is high.

The median basilic vein at the bend of the elbow is that usually opened, since it is larger than the median cephalic, though placed more directly over the brachial artery, from which it is only separated by the bicipital fascia.

The patient should be seated in a chair or in bed; standing would produce syncope too rapidly, whilst the recumbent posture would allow too great an abstraction of blood before Nature's danger-signal (*i.e.*, syncope) is evident. The skin in front of the elbow is purified, and a circular compress is tied round the arm with sufficient tightness to arrest the venous circulation, whilst the arterial supply is unimpeded. Grasping a stick or bandage firmly causes the veins to become prominent. The median basilic is now steadied by the left thumb, and an incision made into it. Blood will flow from it in a full stream, and is collected in the bowl. When sufficient has been withdrawn, the patient's grasp is relaxed, a sterilized swab is pressed over the bleeding spot, the bandage above removed, and a pad of sterilized dressing placed over the wound, and firmly bandaged in position; the arm is kept at rest for a few days to allow the small incision to heal. Occasionally neuralgic pain is caused by the implication of some of the fibres of the internal cutaneous nerve in the cicatrix; whilst, if the lancet is plunged too deeply, an arterio-venous wound may be produced.

Intravenous Medication.—So many drugs are now administered by the intravenous route, especially the salvarsan group, that it is essential for medical practitioners to familiarize themselves with this means of treatment. An evening spent in a venereal clinic will be more profitable than pages of description, but it is sufficient here to suggest the necessity for absolute sterilization of the appliances employed and of the skin over the site of injection. One of the veins of the forearm is selected and caused to become distended by the application of a bandage above, whilst the fist is alternately clenched and opened. The needle is passed through the skin alongside the vein for a short distance and then driven through the wall, thus making an oblique puncture. The bandage is at once released, and the injection then made. Of course, care is taken to avoid the risk of injecting air. No dressing need be applied to the minute puncture, but it may advisably be dabbed over with tincture of iodine.

Angiomata.

Tumours of bloodvessels present varying appearances according to the situation and the character of the vessels of which they are composed. They are frequently of congenital origin or developed soon after birth. They involve most commonly the skin or mucous membrane, together with the underlying tissues, and are then known

as **nævi**; but they are occasionally acquired and develop in deeper organs, such as the liver. According to their structure they are divided into three main groups: the simple or capillary nævus, the cavernous nævus, and the plexiform angioma.

1. The simple or **Capillary Nævus** (mother's mark) is exceedingly common, and consists of a mass of dilated capillaries held together by a small amount of connective tissue. It is usually located in the skin, but may also involve the subcutaneous tissues; the tubular form of the constituent vessels always remains. It occurs in the form of a slightly raised flattened mass, bright red or purple in colour, according to the relative amount of arterial or venous blood present, and with occasionally a somewhat irregular or nodulated surface, in which larger vessels may be seen ramifying. Several such growths may be present in the same individual, and they are usually quite small, rarely exceeding an inch or two in diameter; they are present at birth or appear soon after. The head and face are the parts most commonly affected. Angiomata of the mucous membranes are often a source of considerable danger and trouble from hæmorrhage, especially in the bladder and nose.

A more superficial variety known as the **port-wine stain** often extends widely over the face and neck, and is somewhat dusky in colour; this condition consists merely of a network of fine vessels, and does not project above the surface.

Occasionally a nævoid development may be observed having a linear distribution down the long axis of a limb, or running transversely half round the trunk, and limited almost exactly by the middle line; this condition is known as *nævus unius lateris*. It may consist purely of a vascular manifestation, or the skin may be hypertrophied and covered with small soft papillary excrescences.

The term **Spider Nævus** (*N. araneus*) is applied to a small angioma, which develops usually in young people, and generally on the face, from which radiate a considerable series of fine red lines. When irritated they bleed easily, but are readily cured by the application of carbonic acid snow or a pointed cautery.

It is not uncommon in middle-aged people to find a number of small red spots on the trunk, which sometimes persist for a while and then disappear. These **telangiectases** (or *De Morgan spots*) consist of dilated capillaries, and are possibly degenerative in origin.

Left to themselves, simple nævi may remain unchanged, or disappear; more often they increase in size more or less rapidly, and may invade surrounding tissues, requiring active treatment in order to check their progress. Sometimes they persist unaltered till middle life, and then may increase rapidly, giving rise to a considerable vascular tumour, purple in colour, and occasionally becoming prominent and pendulous. Such a tumour is soft and easily compressible, being in reality a cavernous angioma; it may ulcerate, and profuse hæmorrhage may result.

Treatment is usually simple in the extreme. Small superficial nævi

can be completely cured by some form of cauterization, the best results being obtained by the use of carbonic acid snow. Appliances for the supply and employment of this agent are obtainable from instrument makers. In exposed situations electrolysis (p. 312) may be the best plan to adopt, but excision will often give a good result. Radium may be used in some cases.

2. A **Cavernous Nævus** (Fig. 121) most commonly involves the subcutaneous or submucous tissues, but is sometimes associated with a superficial nævus. It consists of dilated spaces where the tubular form of the constituent vessels is lost, the arteries often opening directly into thin-walled cavities lined with endothelium without the intervention of capillaries. The tumour thus produced is a more or less prominent swelling, soft to the touch, and easily compressible, but refilling when the pressure is removed. There is usually no pulsation or bruit, although both may be present, and the

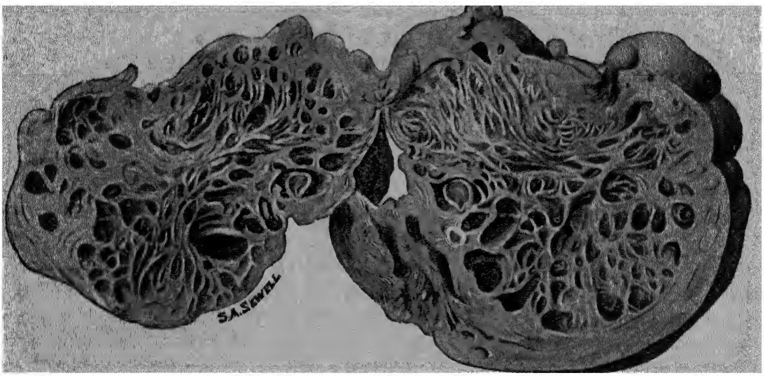


FIG. 121.—SECTION OF CAVERNOUS ANGIOMA (MUSEUM OF ROYAL COLLEGE OF SURGEONS.)

In one or two of the cavernous spaces thrombi more or less adherent can be seen.

mass may be definitely circumscribed, or more or less diffuse. If subcutaneous, the skin over it is somewhat bluish in colour; when the skin is involved, the mass presents a dusky red appearance. Occasionally these growths undergo spontaneous cure from inflammation and thrombosis, and cysts are sometimes found in the centre of a nævoid mass, indicating that a partial attempt at this process has occurred. A similar condition arises in the viscera, especially the liver, and it is not difficult in certain suitable cases to demonstrate that it has been formed by a dilation of the capillaries between the lobules, the liver substance meanwhile disappearing by a process of simple atrophy.

The **Treatment** is by no means as simple as in the former variety. The following plans may be mentioned:

(1) Excision of the growth should always be adopted where practicable. The bleeding is never great, even if the nævoid tissue

is encroached upon by the knife, and only a few vessels will need to be tied. Circular growths should be removed by crescentic incisions, and a little undercutting will usually enable the edges to be approximated.

(2) Where excision is impossible, **diathermy cautery** should be employed. It consists in the passage of an electric current through the mass, producing chemical and physical changes in the contained blood.

3. **Plexiform Angioma.**—This term is now generally applied to an angioma in which the arterial element predominates, although veins and capillaries are also present. The growth is usually seen in young people, and affects most frequently the scalp, especially the temporal or occipital regions. A tumour is produced which is soft and compressible, pulsating forcibly, and with a marked bruit (**cirsoid aneurism,** *q.v.*). It usually consists of large obvious dilated pouches, the skin over which is thinned, and may give rise to serious hæmorrhage, or grave infective troubles. Sometimes the growth consists of smaller arteries, and partakes more of the character of an arterial nævus, but the tubular condition of the vessels is often lost. This variety (**aneurism by anastomosis**) is found in the interior of bones, in some forms of pulsating exophthalmos, and in the scalp.

A **Nævo-Lipoma** is the name given to a somewhat rare tumour, in which a fatty element is blended with nævoid tissue. It is usually of congenital origin, or at any rate appears early in life. It gives rise to a swelling, lobulated and doughy, like a fatty tumour, although it is often rather denser in texture than the ordinary lipoma. It may be possible to reduce its size by compression, but no thrill or pulsation can be detected; a few dilated veins or capillaries are often seen on the surface. The only treatment is excision.

CHAPTER XV.

DISEASES OF THE LYMPHATICS.

Rupture or Division of the Thoracic Duct may occur as a result of a penetrating or bullet wound of the neck, or during operations in the supra-clavicular fossa. The main trunk has also been torn in a fracture of the spine, and the lymph has escaped into the pleural cavity. Wounds near the outflow into the junction of the jugular and subclavian veins usually involve one or more of the several branches into which the main trunk divides before opening into the venous system; lymph or chyle escapes, but if the divided vessel is tied, no further trouble arises as a rule. Failing ligature, the wound should be packed with gauze, and the flow generally ceases after a while. Should this not occur, an attempt must be made to anastomose the divided end of the duct with one of the deep veins, for a persistent and excessive loss of lymph means the exhaustion of the patient.

In a few cases the opening of the thoracic duct has been *obstructed* or compressed, leading to such backward tension that the receptaculum chyli has ruptured and the peritoneal and pleural cavities have been flooded with a serous or chylous exudation. Virchow described one case where the opening was congenitally absent (in a calf), and the lymphatics throughout the body were enormously distended, especially those of the small intestine.

Acute Lymphangitis, or Inflammation of the Lymphatic Vessels, ensues almost invariably from the absorption and passage along the lymphatics leading from an infected wound of bacteria (usually streptococci) and toxins, which give rise to inflammation of the lymphatic vessels involved and of the tissues around them, and this may even run on to suppuration. The walls of the lymphatics become hyperæmic and infiltrated, and the tissues around are inflamed. The lymph coagulates in the vessels, forming a pinkish clot. This process is usually limited by the nearest lymphatic glands, which arrest and filter off the toxic products, with or without the occurrence of suppuration; but, in spite of this, a general infection of the system occasionally results.

Clinical Signs.—The causative wound may be obviously infected, or is possibly very slight and covered by a dry scab. The charac-

teristic appearance is that of fine red lines or streaks following the course of the lymphatics, perhaps up to the nearest glands; the parts thus inflamed are tender and œdematous. If the mischief is limited to the main trunks (*tubular lymphangitis*), they may be felt hard and cord-like, and the red lines remain isolated from each other; but if all the smaller lymphatic channels of a part are affected (*retiform lymphangitis*), the redness merges into a generalized blush, and the condition is identical with cellulitis. Localized foci of suppuration in the course of the lymphatics often follow, the redness increasing and the parts becoming dusky and brawny, until finally the centres soften and fluctuate. These phenomena are associated with fever and malaise, the temperature rising to 102° or 103°, possibly attended by rigors, vomiting, and diarrhœa.

Under suitable treatment resolution rapidly follows, but suppuration may occur either in the glands or in some loose mass of cellular tissue traversed by the lymphatic trunks, or as a chain of abscesses in the course of the vessels. Occasionally the lymphatic vessels become permanently occluded, and a form of solid or lymphatic œdema results. Recurrent attacks of this type are not uncommon in connection with chronic eczema or ulcers of the leg, and may lead to elephantiasis. In the worst cases the patient dies from general septicæmia, or from exhaustion following diffuse suppuration.

Treatment is at first directed to the causative focus, which must be cleansed and fomented so as to cut off the supply of bacteria and toxins to the lymphatics. The limb itself is kept at rest in a slightly elevated position, and fomented or soaked in a hot bath; Bier's treatment of induced hyperæmia is sometimes useful. Abscesses are opened as soon as they develop. Any subsequent œdema is remedied by massage and firm bandaging, provided no venous complications are present.

Constitutional treatment consists in the administration of a purge, followed by a light and nutritious diet, quinine and tonics, care being taken that constipation is not thereby produced.

Chronic Lymphangitis either results as a sequela of an acute attack, or is met with as a separate condition. It is most frequently seen in connection with venereal disease, the dorsal lymphatics of the penis becoming enlarged, hard, and cord-like, especially in cases of primary syphilis. This is usually accompanied by a solid œdematous condition of the prepuce and enlargement of the inguinal glands. Under appropriate antisyphilitic treatment, the swelling quickly subsides.

A *tuberculous* type of chronic lymphangitis also exists in which a primary focus, say, on a finger, is associated with secondary deposits along the lymphatics up the arm. Each nodule is at first of firm consistency, but gradually softens and breaks down. Naturally, such a case is liable to be followed by general dissemination. The *treatment* consists in the excision, if possible, of each focus.

The cheeks and nose are occasionally the seat of a chronic relapsing lymphangitis, due to the absorption of septic material

from sores within the nostril. It is characterized by patches of hyperæmia and some amount of tissue infiltration, and for its cure the causative lesions must be treated. The thick lips of a tuberculous child are of a similar nature, and due to the constant irritation of cracks along the lip margin.

Lymphatics, like bloodvessels, are liable to distension and dilatation, which may be either congenital or acquired, and are known as **Lymphangioma** or **Lymphangiectasis.** It is impossible to draw an absolute line of distinction between the two conditions, but the latter term is applied mainly to cases where normal lymphatics are dilated and their continuity with the normal lymphatic circulation persists, whilst a lymphangioma is the result of a new formation. Not unfrequently the two conditions develop side by side.

Lymphangiomata are growths composed of newly-formed lymphatics, together with a variable amount of connective tissue, which is sometimes of a fatty nature. They may be congenital or acquired, but even in the latter case there is probably an underlying congenital element, which was only awaiting some irritation or localized injury to determine its development. Two varieties may be described, the capillary and cavernous.

(*a*) The **Capillary Lymphangioma** is usually congenital in origin, but often increases considerably as the child grows, and may attain large proportions. When developing in the skin, it may be termed a **lymphatic nævus,** and in origin and development it well merits the title. The patch is usually of a dull yellowish-brown colour, but this varies with the amount of blood present; it may be smooth-topped like a wheal, or wart-like in appearance, but on examination with a lens each projecting point contains a vesicle. This type of growth is sometimes very extensive, and may be associated with tumours of the underlying connective tissues. Thus, a large fatty mass was removed from the anterior thoracic wall of a child, the greater portion of the projecting surface of which was covered with a capillary lymphangioma. The only *treatment* for this condition is excision or cauterization.

In the subcutaneous tissues the capillary variety is often associated with large cysts of the cavernous type. It constitutes a soft swelling which when cut into has a spongy texture and exudes a large amount of lymph, with some blood. This form is rarely well defined, and may burrow widely, invading and infiltrating the tissues, and, indeed, in some cases may almost be looked on as of a malignant nature. Free excision is the only cure.

(*b*) **Cavernous Lymphangioma.**—The lymphatics here lose their tubular condition and give rise to cyst-like swellings which vary much in size.

In the skin they are rarely larger than a split pea, and may co-exist with the capillary variety. Any part of the body may be affected, and the lesion manifests itself as a series of small vesicles, which persist and are unaccompanied by any inflammatory redness, thus

serving to distinguish it from herpes. They contain lymph, and, if opened, a considerable flow of this fluid (lymphorrhœa) may result, lasting for some time. They have been observed most frequently on the inner side of the thigh and on the prepuce. **Treatment** consists in excision, or in laying them open and cauterizing the base.

In the deeper structures large multilocular cystic swellings may be produced; these are most frequently seen in the neck, and the condition is often termed a **Cystic Hygroma** (Fig 122). The description given in Chapter XXXV. would apply equally well to a tumour of this nature in any other part of the body. Removal by dissection is often very difficult, especially in old-standing neglected cases; the limitations of the mass are sometimes very indefinite, and it

FIG. 122 —CYSTIC HYGROMA OF NECK.

may be necessary to leave the wound open and pack it, so as to ensure healing by granulation.

Lymphangiectases are more frequently acquired than congenital, but the latter condition occurs, and is then probably due to some abnormal development of the lymphatics or to ante-natal inflammatory mischief.

Macroglossia and **macrocheilia** are congenital enlargements of the tongue and lip, due to lymphatic obstruction and to an associated overgrowth of the connective tissues of the parts.

The condition known as **Chylous Hydrocele**, in which there is an effusion of milky fluid (presumably chyle) into the tunica vaginalis, is probably due to some such obstructive cause. In a case under our care the lymphatics of the spermatic cord were dilated by a similar fluid in a beaded manner.

Elephantiasis is a hypertrophic condition of the subcutaneous tissues and skin resulting from chronic lymphatic obstruction. Two chief varieties are described: (i.) *E. arabum*, due to a development in the lymphatics of living parasites—viz., the *Filaria sanguinis hominis;* (ii.) the *non-filarial* type, which may arise from many

causes, such as the deposit of tuberculous or cancerous material in lymphatic glands; the obliteration of lymphatic channels in operations for removing such glands; or from recurrent attacks of lymphangitis in cases of chronic eczema or ulcer, leading to a gradually increasing obliteration of lymphatics. The condition generally affects the legs, but the scrotum is not uncommonly involved, and occasionally the mammæ, arms, or face. The accompanying illustration (Fig. 123) indicates that the non-filarial type may be just as severe as the other, although this is unusual.

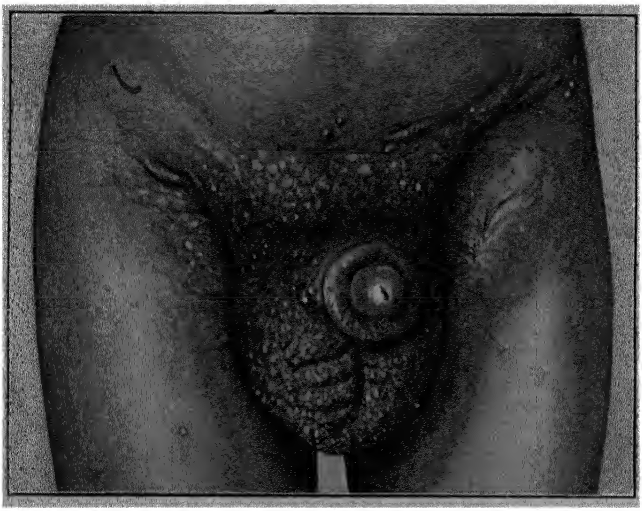


FIG 123.—NON-FILARIAL ELEPHANTIASIS OF SCROTUM, PENIS, AND THIGHS (FROM A PHOTOGRAPH)

The patient was a young man, and the cause of the trouble suppuration of the inguinal glands after scarlatina, the cicatrices of the incisions required in order to deal with the glands are plainly to be seen The scrotum was much enlarged and very solid, the skin over it was covered with papillomatous growths, due to lymphatic dilatation. The skin of the penis was much thickened, and the subcutaneous tissues infiltrated Over the thighs were scattered numbers of vesicles, which, when pricked, exuded lymph, and some of these were becoming transformed into solid fibrous growths The legs and feet were also in a condition of solid œdema.

Three chief phenomena manifest themselves as the outcome of such obstruction—viz., (*a*) *Solid or lymphatic œdema*, a condition in which the subcutaneous tissues become firm, infiltrated, and brawny, but the fluid cannot be expressed from them, as in an ordinary œdema, and hence the part does not pit on pressure. (*b*) *Hyperplasia* follows, affecting not only the subcutaneous tissues, which are greatly thickened, but also the skin, which becomes coarse and wart-like in appearance. (*c*) The warty stage is usually preceded by a development of vesicles (dilated lymphatics) in the papillæ, and from these

when ruptured a considerable flow of lymph (*lymphorrhœa*) may follow. If infection supervenes, chronic ulceration and recurrent lymphangitis may ensue.

Elephantiasis Arabum (see Chapter XLVII.).

The **Treatment** is extremely unsatisfactory. In the *filarial* variety, if one can localize the situation of the parent filariæ, as has been possible in a few cases, they should be excised; but even then the lymphatic obstruction may persist. This may be dealt with in either variety by elevation of the limb and elastic pressure; but when the condition is due to lymphatic obstruction in the groin, it may be possible to find the dilated lymph trunks and implant them into a tributary of the internal saphena vein (*lymphangeioplasty*), so as to relieve the limb of its engorgement with lymph. It has also been suggested to construct artificial lymphatics by introducing a carefully sterilized silk thread through the subcutaneous tissues of the thickened area, leaving it buried therein, and carrying it up into normal tissues (Sampson Handley). This has acted fairly well in draining away the fluid from the brawny arms, sometimes seen in the last stages of a cancerous breast (*q.v.*), but it is of little avail in the lower extremity owing to the counter-influence of gravity. Finally, when a limb is involved, amputation may be desirable. When the scrotum is affected, the morbid tissue can be freely dissected away, sufficient skin being left to cover in the wound if possible; the penis and testes must first be isolated, and then the scrotum amputated, a tourniquet being used to restrain the bleeding.

Affections of Lymphatic Glands.

Acute Lymphadenitis, or Inflammation of Lymphatic Glands.—The **Cause** of this condition is almost always the absorption of some irritative material (toxic or infective) from the periphery. There is always an increased flow of lymph from an inflamed part, resulting in an enlargement of the glands to which the lymph is carried, which quickly subsides when the inflammatory process is at an end. In infective conditions the enlargement is more obvious and painful, and suppuration frequently results; in fact, the lymphatic glands must be looked on as the filters by means of which many sources of disease are eliminated. It is curious that certain peripheral infective conditions are not at all liable to produce lymphadenitis—*e.g.*, spreading gangrene and many forms of cellulitis; possibly the acuteness of the process causes lymphatic thrombosis, and thus hinders absorption. A certain amount of peri-adenitis is always present, even in the early stages; it may be of little importance, or be so severe and extensive as to constitute a diffuse suppurative cellulitis.

Clinical History.—The glandular trouble may be associated with a typical lymphangitis, or be independent of it, and the causative lesion may have almost disappeared before the glands become affected. The glands become enlarged and tender, and if super-

ficial, the skin over them is red and œdematous, and the surrounding tissues are infiltrated and brawny. When pus forms, softening occurs in the centre of the mass, and fluctuation may become evident; where there is much loose areolar tissue around the glands, as in the axilla, the pus may burrow widely. Fever, malaise, and all the general phenomena associated with an acute inflammation, are usually well marked.

Treatment.—The offending wound or causative lesion must be dealt with by such measures as may be needed to hasten its restoration to a healthy state. Fomentations or poultices are applied over the gland, and the patient, after the administration of a purge, may be given quinine and iron, if necessary. As soon as pus has formed, it should be let out by an incision, and the wound dressed antiseptically.

The **Axillary Glands** are usually affected as a result of poisoned wounds of the hand or fingers, although other glands exist lower down in the arm, viz., the supracondyloid, just above the internal condyle. Boils in the axilla and excoriations or infected wounds of the breast may also cause an axillary abscess. In this region a suppurative peri-adenitis is often superadded, extending widely under and between the pectoral muscles, reaching even up to the clavicle (*vide* axillary cellulitis, p. 82). Care must be taken in opening such an abscess to avoid the main vessels by cutting from above downwards, midway between the anterior and posterior axillary folds, whilst Hilton's method should be adopted in all cases where the pus is situated deeply.

In the **Groin** there are three groups of glands: (1) The oblique set, running parallel to Poupart's ligament, and becoming inflamed in affections of the penis, scrotum, perineum, anus, buttock, and lower part of the abdomen; (2) a superficial vertical set, running with the long saphena vein, and receiving lymph from all the superficial parts of the limb, except perhaps those from which the blood is returned by the external saphena vein, the popliteal glands receiving the lymph from this region; and (3) the deep vertical set, receiving the deep lymphatics of the limb. Abscess in the groin is opened by a vertical incision, so as to allow the wound to gape when the patient sits, and prevent pocketing of matter.

Suppuration in the glands of the **Neck** is exceedingly common, arising most often from affections of the scalp (eczema or pediculosis), ear (otorrhœa or eczema), throat, or lips. As to the exact distribution of the lymphatics, we must refer students to anatomical textbooks When opening a cervical abscess, care must be taken to avoid important structures, such as the external jugular vein, and to make incisions across the fibres of the platysma in order to gain space for efficient drainage.

Chronic Lymphadenitis.—Three chief varieties of chronic inflammation of lymphatic glands are met with—viz., the simple, syphilitic, and tuberculous.

1. **Chronic Simple Lymphadenitis** is a condition resulting from some peripheral irritation, which is insufficient to cause an acute attack. Occasionally it is due to blows or to strains, as in over-walking, being then the outcome of obstruction to the lymphatic flow from compression or rupture of the efferent vessels. The glands become enlarged, tender, and painful, but as a rule they are not adherent to one another or to adjacent structures, and show but little tendency to suppurate. This condition often precedes, and, indeed, may be looked on as a predisposing cause of, tuberculous lymphadenitis.

The **Treatment** consists in keeping the part at rest, and removing, if possible, all sources of local irritation. The general health should also be attended to, especially in children predisposed to the development of tuberculous disease.

2. **Chronic Syphilitic Lymphadenitis.**—The lymphatic glands are involved in several ways in the course of syphilitic disease: (*a*) The primary lesion is associated with the development of an indolent bubo in the nearest lymphatic glands (p. 168). (*b*) In the second stage, when general infection has occurred, the glands in many parts of the body are infected in the same indolent fashion (p. 171). (*c*) In the tertiary period the lymphatic glands may undergo a true gummatous change, or become enlarged and tender owing to the absorption of infective material from a broken-down gumma.

3. **Chronic Tuberculous Lymphadenitis** occurs most commonly in children or young adults, and especially in those whose surroundings are unhealthy, and whose general condition is deteriorated by insufficient or bad food and want of fresh air. Some local focus of irritation is usually present in the form of pediculosis capitis, decayed teeth, chronic otorrhœa, adenoids, or eczema of the face. As a result of this, neighbouring glands become chronically inflamed, and, as the late Sir T. Burdon Sanderson expressed it, 'the soil is thereby prepared for the seed.' The bacilli are conveyed to the gland by the blood or lymph, gaining access through some breach of surface, or even through a healthy mucous membrane; or perhaps they may be derived from some deep focus of quiescent tubercle, say in the bronchial or mediastinal glands. Any lymphoid tissue in the body may become the seat of tuberculous disease; but the glands of the neck, which derive their lymph from the mouth, throat, nose, ears, and scalp, are more commonly involved than any others. The axillary and inguinal glands are not unfrequently affected, whilst tuberculous disease of those in the mesentery gives rise to the affection known as 'tabes mesenterica.' For the general facts as to the pathology of tuberculosis, see p. 188.

The earliest manifestation of the disease consists in a *fleshy enlargement* of the glands, which cannot at first be distinguished from a simple chronic hyperplasia. The gland may be enlarged to many times its natural size, and on section looks pinkish in colour, and is of firm consistence. Microscopically, all that is noticed is a great increase in the lymphoid corpuscles, together with some overgrowth and thickening of the fibrous capsule and trabeculæ. When tuberculous infection has occurred, the characteristic nodules can be seen under the microscope, but there is at first no change in the naked eye appearances. *Caseation* follows sooner or later, appearing as foci scattered through the gland, which gradually coalesce to constitute larger masses, which may in time involve the whole (Fig. 124). Should the case recover without suppuration, the gland gradually shrinks, and becomes small, hard, and often closely adherent to surrounding tissues, whilst the caseous material is absorbed, or undergoes *calcification*. This latter change is often seen in the

mediastinal and mesenteric glands, but is not very common in the neck.

More frequently *suppuration* ensues, sometimes from a simple liquefaction of the caseating material, sometimes from a superadded infection with pyogenic organisms. Foci of pus develop at various spots in the parenchyma, and when once formed, these gradually amalgamate and cause the destruction of the rest of the gland. Several of these abscesses may unite one with another, and thus a large multiloculated cavity containing pus mixed with caseous débris is formed. A certain amount of *peri-adenitis* is almost always present, though not to any great extent in the early stages; when, however, suppuration has occurred, the enlarged glands become adherent to one another and to surrounding structures. In the more chronic cases the fibro-cicatricial tissue thus formed may be so extensive as to fix the mass firmly to the deeper parts, such as the main vessels and nerves, rendering removal dangerous and almost impracticable. Important vessels are occasionally eroded by an extension of the suppurative process, and this may lead to fatal hæmorrhage. Sooner or later the abscess, if left to itself, bursts at one or several spots, giving exit to the pus and caseous débris, and leaving ulcerated openings, which are surrounded by skin that is undermined, thin, and purplish, and through which granulations protrude. A variable amount of pus escapes from these until all the caseous material has disappeared, so that the condition may persist for many years before healing occurs, and even then the *cicatrix* is

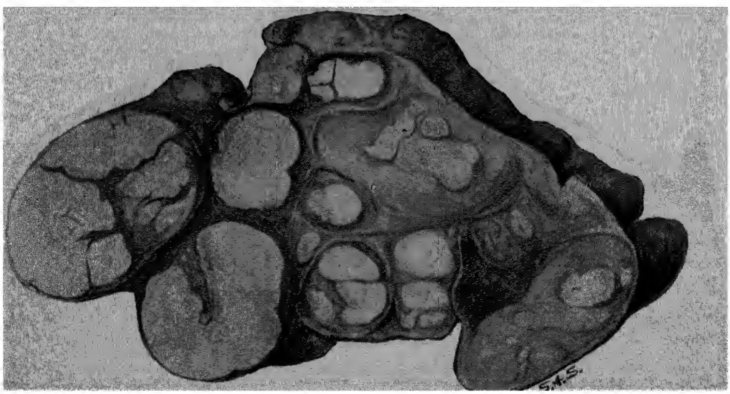


FIG. 124.—CHRONIC TUBERCULOUS GLANDS WITH MULTIPLE FOCI OF CASEATION. (KING'S COLLEGE HOSPITAL MUSEUM.)

often puckered and more or less keloidal, and may retain its vascularity for a much longer period than would a healthy scar. Lymphatic œdema in the region drained by the affected glands is sometimes observed as a late consequence of this affection.

Treatment in the early stages consists mainly in improving the

general health by means of suitable diet and tonics, such as cod-liver oil and syrup of the iodide of iron, together with residence in a healthy, bracing place, especially at the seaside or on high moorland. All sources of local irritation, septic roots of teeth, enlarged tonsils, adenoids, etc., must be removed so as, if possible, to prevent infection with pyogenic organisms; and counter-irritants, such as iodine paint, are best avoided. Rest of the affected part should be enforced as much as possible; in some cases the application of splints to restrict movement is advisable. Exposure to radium is sometimes useful.

Operative treatment at the present day consists in little more than the aspiration of abscesses when they develop, granting that the overlying skin is healthy. Should the case have been neglected and the skin become red and thinned, the abscess must be opened, and all tuberculous material scraped away, the cavity being subsequently 'bipped,' packed with gauze, and allowed to granulate. It must be remembered that in the neck there is frequently a deep subfascial origin to abscesses, the superficial collection of pus communicating by a small opening in the fascia with a deeper focus of caseous material (collar-stud abscess); unless this latter is dealt with and the caseous detritus scraped away, the wound is unlikely to heal.

If effective treatment of the sanatorium type (p. 194), including exposure to sunlight, the ultra-violet rays of an arc lamp, or to radium, is instituted sufficiently early, extirpation by operative measures will be seldom required, and even then should be limited to isolated groups of glands, such as occur in the anterior or posterior triangles, or the submental region of the neck, or in the axilla. Under no circumstances should the mutilating operations formerly described as desirable in order to remove all enlarged glands in the neck be countenanced. Extensive involvement of the glandular area of this type must be dealt with by intensive sanatorium treatment, as it usually connotes more generalized disease than is immediately apparent.

Occasionally it is justifiable to excise ugly keloidal scars for cosmetic purposes, but only when the glandular trouble has absolutely ceased.

The *pre-auricular gland* lying on the capsule of the parotid is sometimes affected, and may cause facial paralysis, either as a result of the sclerosing peri-adenitis, or from injudicious surgery. Any incisions made with a view to remove the gland or to open an abscess therein should be made in the direction of the fibres of the facial nerve—*i.e.*, horizontally.

In the *groin*, tuberculous glands are often mistaken for some condition due to venereal disease. The history of onset and the extreme chronicity should suffice to establish a diagnosis. The iliac glands will often be found similarly affected, and well-marked peri-adenitis is usually present.

Tumours of Lymphatic Glands.

Lymphadenoma, or **Hodgkin's disease,** is characterized by a progressive enlargement of the lymphatic glands and of the lymphoid tissue of the spleen, liver, and other organs. The affected glands and the masses in the viscera are quite characteristic in structure, and have a very different appearance from that seen in simple hyperplasia or in infective processes. The gland is homogeneous on section, the distinction between cortex and medulla being lost. The amount of stroma varies considerably, and the glands are hard or soft according to its relative abundance or not. One type does not appear to pass into the other, and the soft form is, in most cases, more malignant and more rapid in growth than the hard. There is a relative decrease of lymphocytes in the glands, and an increase in the endothelial elements, some of which are multi-nucleated. Nothing is known as to its cause, but it is probably an infective disease.

Hodgkin's disease is generally seen in young adults, but no age is exempt; it is decidedly more common in males than in females. In some cases the cause of the original enlargement of glands is some inflammatory lesion, such as otitis media or dental caries, but often no such origin can be traced. The glands first affected are usually the cervical, and the disease may remain limited to a larger or smaller group of these for a considerable time before other manifestations show themselves. In other cases internal glands become affected first, and this most commonly in the mediastinal group, the retro-peritoneal glands coming next in order of frequency. When the disease is more advanced, lymphadenoid tissue in any part of the body may be affected. The spleen is usually somewhat enlarged, and in about half the cases presents localized grayish-white tumours (the *hard-bake spleen*). Similar growths may occur in the liver, kidneys, etc., or in the skin.

The early symptoms are slight, the only thing noticed being the glandular enlargement. In this stage the glands are soft and elastic, and not adherent to the skin or to one another. When the internal glands are first affected, the earliest symptoms may be those of pressure. This is most marked in the mediastinal group of cases, in which pressure on the superior vena cava is early noted, leading to engorgement of the superficial thoracic veins.

In the later stages intermittent febrile attacks appear, associated with swelling and pain in the glands, possibly due to a superadded pyogenic or tuberculous infection; peri-adenitis results, and the glands often fuse together, forming hard masses of large size, whilst the disease becomes generalized. The blood shows a moderate grade of anæmia of the secondary type, with a slight increase of leucocytes, especially of the lymphocytes. Gradually the pyrexia becomes more constant, and the patient passes into a cachectic condition.

Diagnosis.—(1) From *lymphatic leucocythæmia* Hodgkin's disease is recognized by the entire absence of blood changes in the

early stages, and by the presence merely of a secondary anæmia in the later. Moreover, lymphadenoma usually limits itself to regions in which adenoid tissue is normally present; leucocythæmia may develop new growths in any part of the body. (2) From *lympho-sarcoma* it is known by the fact that it is almost invariably limited to the glands, and does not infiltrate surrounding tissues. Lympho-sarcoma is characterized chiefly by its tendency to infiltrate, and also by producing secondary deposits in tissues which are not rich in adenoid tissue. (3) From *tuberculous disease* of glands the diagnosis is often difficult. Tubercle is more common in the very young, and is more frequently bilateral. The glands have a greater tendency to fuse together as a result of peri-adenitis and to suppurate. In doubtful cases microscopic examination of an excised gland may be required to settle the diagnosis.

The **Treatment** of Hodgkin's disease consists in the administration or arsenic and the exposure of the enlarged glands to X rays or radium. Arsenic must be administered in the form of intravenous salvarsan; oral administration is of little use. X rays seem to have a marked and rapidly beneficial effect over this condition. Operative treatment is useless; in the early stages it is easy, but unsuccessful, as recurrence almost invariably follows; in the later stages, when several attacks of inflammation have occurred, it may be most difficult, and indeed practically impossible, to remove the glandular masses. Unfortunately the good effects of arsenic and irradiation cease after a time, and nothing suffices to hinder the downhill progress of the patient.

Lymphatic Leucocythæmia is of little surgical interest except in so far as it simulates Hodgkin's disease. The symptoms are much more severe than in the latter, and marked blood changes are present; the number of the leucocytes is enormously increased, reaching 150,000 or more per cubic millimetre, and there is a great preponderance of lymphocytes, which constitute from 90 to 99 per cent. of all white cells present. There is also anæmia, often of some severity. It is often asso iated with changes in the spleen and medulla of the long bones, characteristic of the spleno-medullary type of leucocythæmia. In its treatment arsenic is of some value, and X-ray treatment directed to the spleen and ends of the long bones, as well as to the glands, has been used with temporary benefit. It is also stated that if the patient's general condition can be improved sufficiently by blood transfusion, removal of the spleen is beneficial and curative; but the danger of the operation is considerable, and sufficient time has not yet elapsed to dogmatize as to results.

Lympho-Sarcoma.—This term has been used with very different meanings, but is best restricted to tumours which have a structure approximating to that of lymphadenoid tissue—*i.e.*, which consist of small round cells, resembling, if not identical with, ordinary lymphocytes, set in a reticulated stroma; there is no distinction between cortex and medulla. They closely resemble a small round-

celled sarcoma, except that the stroma is more obvious; their sarcomatous nature is evidenced rather by clinical than by histological characters—viz., by the fact that they invade and destroy surrounding tissues.

Lympho-sarcoma may commence in any part of the body, but in the vast majority of cases it originates in pre-existing adenoid tissue, most commonly in the glands at the root of the neck, the tonsil, or the mediastinum. It may also affect the intestines (commencing probably in the Peyer's patches) or the testis. When developing in a region where its progress can be followed, it is seen to form a rapidly-growing tumour, which is at first firm, elastic, and painless; later on, however, as it increases in size, it becomes tender, and may cause great pain from pressure on, or implication of, nerves. It early contracts adhesions to surrounding parts, and gives rise to secondary growths in neighbouring glands by direct transmission. The superjacent skin is at first unaltered in colour and texture, but as the tumour increases it becomes congested and shiny, and contains a network of dilated veins. Finally, ulceration occurs, and is followed by the sprouting up of a bleeding fungating mass, similar in character to that formed by any other rapidly-growing malignant tumour. Dissemination of the growth throughout the viscera follows, death resulting from exhaustion and cachexia.

The **Treatment** consists in the removal of the mass, where practicable, without delay, and subsequent radio-therapy. If, however, extensive adhesions exist, this becomes absolutely impossible, and radio-therapy can alone be relied on.

Secondary Growths in Lymphatic Glands are a special feature of all cancerous tumours and melanomata. In the sarcomata they are less common, but are always present in the case of lympho-sarcoma, and usually in sarcoma of the testis, tonsil, and thyroid The special characteristics of these are noted elsewhere.

CHAPTER XVI.

AFFECTIONS OF NERVES.

Contusions and **Strains** cause a sensation of tingling, or of pins and needles, which usually wears off in the course of a few hours. In severe cases variable degrees of loss of power and sensation may ensue, associated with more or less neuralgia, and in patients suffering from gout, syphilis, or rheumatism chronic peripheral neuritis develops, often of a somewhat intractable type. **Treatment** consists in friction, with stimulating liniments in the slighter cases.

Concussion of a nerve is characterized by the more or less complete loss of its function without any apparent lesion. It has been frequently observed as the immediate result of the passage of a bullet or fragment of shell close to a nerve. There is no shooting pain associated with the injury, and the anæsthesia does not correspond with any definite peripheral nerve distribution, but is limited to the area over which the loss of power is confined. The muscles rarely waste, and faradic excitability persists. Apart from infection, repair shows itself within two or three weeks, and is usually completed within three or four months. If, however, the wound becomes infected, the condition may be followed by compression due to cicatricial contraction. It is probable that the loss of conductivity is due to molecular disintegration of the axis cylinders or to minute hæmorrhages.

Massage and electricity are desirable elements in the treatment, but in the later stages much can be done by suggestion and persuasion.

Compression of a nerve may arise from many different causes, and the clinical picture varies somewhat according to the history and the particular nerve involved. (1) It may be due to *direct traumatism*—*e.g.*, the pressure of a crutch in the axilla, the musculo-spiral nerve being generally affected; the presence of a cervical rib may cause pressure on the lower brachial nerves (p. 428); undue prominence of the ulnar nerve behind the elbow, perhaps due to cubitus valgus, exposes it frequently to injury; or a superficial nerve may be compressed between a splint and an underlying bone, as where the external popliteal nerve passes over the neck of the fibula. (2) It may be caused by the *contraction* of cicatricial tissues in an infected wound, or by the development of *callus* in a fracture—*e.g.*, the musculo-spiral in fractures of the shaft of the humerus, whether

open or closed. Some immediate loss of function may result either from concussion or partial laceration, or from a combination of these factors. Improvement of the symptoms may for a short time accompany healing of the wound, but subsequently the nerve is constricted by contraction of the scar tissue. (3) *Tumours and aneurisms* frequently produce nerve compression.

In the majority of cases the symptoms are more or less similar. Irritative phenomena appear early, and are manifested by cramp or spasm of muscles, associated with neuralgic pain; later, there is loss of function of the muscles supplied by the damaged nerve, together with anæsthesia, corresponding to its peripheral distribution. As a rule, the paralysis is incomplete, the nerve not being divided, and wasting is not generally a prominent feature. The loss of protopathic sensation (pain on pin-prick) is greater than that of the epicritic sense (touch with camel-hair brush), which is contrary to that usually seen in division of a nerve (Stopford). Some degree of recovery may be looked for after removing the cause of the compression, and the progress will depend upon the amount of permanent structural change which the nerve has sustained. In many cases operative measures (*neurolysis*) are indicated, and care must be taken to prevent the recurrence of the development of scar tissue. Implanting the nerve within a healthy muscle belly or wrapping it round with an autogenous pad of fat are probably the most satisfactory methods of securing this end. In some cases the cause can be effectively dealt with, as by removal of a cervical rib, or by transplanting the ulnar nerve from the back to the front of the internal condyle.

The nerve is sometimes merely *adherent* to a scar, in which case the main symptom is pain brought about by movements which drag on the nerve. The prognosis of these cases is fairly good, providing the nerve can be freed and protected from further pressure by a fatty pad. Ionization of the scar or its treatment by radium emanations may be tried as a preliminary measure.

Rupture of nerves without an external wound only occurs in connection with severe injuries such as dislocations or fractures, and even then total division is rare, the sheath retaining its integrity, although the axis cylinders may have given way. Immediate paralysis and loss of sensation usually follow, and may persist for a time, although repair not unfrequently occurs, since the sheath remains intact. The doubt always existing as to the condition of the sheath regulates the **Treatment** which must be followed—viz., one of expectancy. Massage and electricity should be applied to the affected muscles, which are placed in a position permitting their complete relaxation so as to prevent them from stretching; only when a sufficient trial has been given to these should operation be undertaken. Secondary nerve suture under these circumstances is not a very successful proceeding.

Total Division of a Nerve may result from any type of penetrating wound—*e.g.*, stabs, or from the missiles used in war. In civilian

practice wounds produced by ragged fragments of glass are often associated with nerve injuries. At the moment of infliction of the wound the patient usually experiences a sharp shooting neuralgic pain, which he describes as similar to an electric shock, shooting up or down the limb. X 1-9-40

The **Immediate** effects are: (*a*) Paralysis of the muscles supplied by the nerve; (*b*) complete anæsthesia of the parts supplied by it, which, however, is not necessarily permanent, since sensation may be conveyed by collateral trunks, the anæsthetic area passing through gradual stages of partial sensation before recovery is complete (*c*) Vasomotor paralysis is also produced, the limb becoming hyperæmic and warmer for a few days, and then subsequently colder and insufficiently supplied with blood. (*d*) The excito-secretory nerves are paralyzed, so that glands lose their functions for a time.

FIG. 125.—TRAUMATIC NEUROMA OF POSTERIOR TIBIAL NERVE AFTER AMPUTATION OF LEG (FROM KING'S COLLEGE HOSPITAL MUSEUM.)

The **Secondary** effects vary with the character of the nerve injured, whether motor, sensory, or mixed; with the condition of the wound, whether infected or not; and with the possibility or not of early coaptation of the divided ends.

1. **Changes in the Nerve.**—*Locally*, the two ends retract, and the space thus formed fills with blood, which is quickly absorbed and replaced by granulation tissue, and this in turn by a bulb-like mass of fibro-cicatricial tissue (*terminal neuroma*), within which are found spaces filled with fine nervous fibrillæ coiled up in loops. After an amputation, most of the divided nerves are found to have developed these typical bulbous ends (Fig. 125), whilst in nerves accidentally severed in their continuity the bulbous mass which forms on the upper end is separated by an interval from the atrophied lower end, though there is often a fibrous connection between the two (Fig. 127, A). These bulbs may be the seat of severe neuralgia. In a few rare instances immediate union of a divided nerve is supposed to have occurred, as indicated by total and rapid restoration of function. 2-9-40.

Peripherally, the so-called Wallerian degeneration commences about the fourth day after the accident, in consequence of the separation of the nerve from its trophic centres. The medullary substance undergoes a form of segmentation, and is broken up into irregular masses of myelin, which are absorbed by leucocytes or

connective-tissue cells, and disappear entirely in about a month. The axis cylinders also degenerate and disappear. The neurilemma cells proliferate in columns and form a fibro-cellular rod, in which all power of conducting nervous or electric stimuli is lost.

2. **Changes in the Muscles.**—Complete paralysis of motion necessarily occurs when a motor nerve has been divided, and the muscles involved waste and undergo degeneration. The atrophy is not so rapid as that arising from infantile palsy, since it is simply due to separation from the trophic centres, and not to their destruction. Unless the paralyzed muscles are kept in a position of relaxation, they become stretched and elongated, and then, even if satisfactory repair of the nerve is secured, restoration of function is almost impossible. For example, in musculo-spiral paralysis all the extensor muscles of the wrist and hand become hopelessly elongated unless the wrist is maintained in a position of hyper-extension on a 'cock-up' splint.

The *electrical* changes, too, are important. The faradic current rapidly loses its power over the paralyzed muscles, and its effects totally disappear in two or three weeks, whilst the galvanic excitability remains for weeks or months, and even then only slowly diminishes, so that a condition develops in which the galvanic current produces a much greater contraction than the faradic (*reaction of degeneration*, p. 310). As long as this phenomenon remains, there is a hope that restoration of the continuity of the nerve may be followed by restoration of function; but when the muscles react neither to galvanic nor to faradic stimuli the case may be looked upon as beyond repair.

3. Various modifications of **Sensation** are produced. Head and Sherren* have demonstrated that different types of sensory impulse are carried by separate groups of nerve-fibres, and that the peripheral distribution of these varies considerably. (*a*) *Deep* sensation consists in the appreciation of pressure, including heavy touch and painful pressure, and in the recognition of the positions and movements of joints and muscles. These stimuli are carried by motor nerves, and distributed to muscles, tendons, ligaments, etc. Section of all the sensory nerves to the skin of a part does not destroy this form of sensation. (*b*) *Protopathic* sensation takes cognizance of painful cutaneous stimuli, and of the effects of temperatures below 20° and above 50° C. The distribution is somewhat indefinite and diffuse, following rather the nerve-root areas than those of the peripheral nerves. The superficial extent supplied by a particular nerve is only recognized when all other sensory nerves to the part are divided, and is liable to vary considerably. The overlapping of these areas will explain the persistence of certain forms of sensation when the nerve apparently supplying that area has been divided. (*c*) *Epicritic* sensation includes the appreciation of light touch (as by a wisp of wool), the localization of stimuli, the recognition of moderate degrees of temperature (between 20° and 40° C.), and the power

* *Op. cit.*, James Sherren, 'Injuries of Nerves and their Treatment,' 1908.

of discriminating between two stimuli simultaneously applied, as by the points of a compass; its distribution corresponds with fair accuracy to that of the peripheral nerves.

Section of a purely sensory nerve causes loss of the epicritic and protopathic forms of sensation only, but the area over which the epicritic sense is lost (Fig. 126) is greater than that over which protopathic sensation is absent owing to the overlapping of neighbouring nerve areas. Section of a mixed nerve causes loss of all three types of sensation in any area exclusively supplied by that nerve, but if there is much anastomosis with neighbouring nerves protopathic sensation is little affected. Section of a posterior nerve-root affects protopathic sensation more extensively than the epicritic. In in-

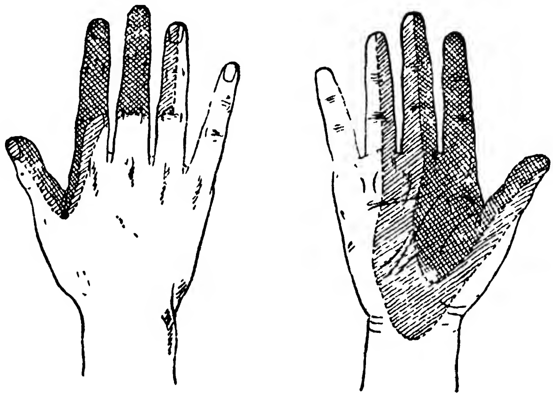


FIG. 126.—USUAL TOPOGRAPHY OF SENSORY DISTURBANCE AFTER SECTION OF THE MEDIAN NERVE. (AFTER TINEL.)

The area of lighter shading is one of hypo-æsthesia; that more darkly shaded is completely anæsthetic.

complete division or injury of sensory nerves, epicritic sensation is abolished more extensively than protopathic.

4. The blood-supply to a paralyzed part is diminished, and the circulation feeble; hence the extremities usually become cold and their vitality lowered. Chilblains are readily produced, and the unwise application of heat may cause blistering or even sloughing. Wounds heal badly, and ulceration from slight irritants is very likely to occur—*e.g.*, corneal ulceration after division of the fifth nerve, and perforating ulcers of the foot after division of the sciatic nerve. Atrophy of the smaller bones may follow, and ankylosis of the terminal joints of the fingers or toes. In a growing child the development of the part is always more or less impaired. As a general rule, the sweat secretion ceases, and the skin over the anæsthetic area becomes dry and scaly, so that one can often see its extent and limits. All these phenomena are more marked when some irritative pressure exists, as by a foreign body or the presence of scar tissue.

5. In a few cases changes have developed in the central nervous system which are of much interest. In the early stages reflex spasms or paralyses are sometimes met with as temporary phenomena; at a later date more serious symptoms may result, such as epilepsy, but the explanation is not easy.

Incomplete division of nerves is by no means uncommon, especially in wounds produced by the penetration of fine cutting instruments, or of small conical bullets or of fragments of high-explosive shells.

Should the nerve be notched, the divided fibres retract and leave a gap, which, after a time, is filled by a fibrous mass permeated with embryonic axis cylinders, constituting a **lateral neuroma** (Fig. 127, B), over which are spread the undivided fibres of the nerve. This neuroma may be adherent to the scar tissue which reaches the skin, and may be the site of severe neuralgic pain.

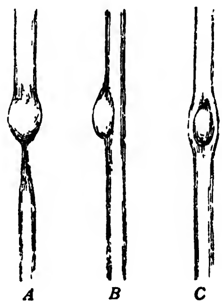


FIG. 127.—DIAGRAMS OF FORMATION OF NEUROMA ON INJURED NERVES.

A, Total division with terminal neuroma; B, partial division with lateral neuroma; C, perforation with central neuroma.

A large nerve-trunk is sometimes penetrated by a small fragment of metal or missile, and some of its central fibres divided; in such cases a **central neuroma** (Fig. 127, C) may develop, around which pass the healthy nerve-fibres, and the bulbous enlargement so produced can often be felt from outside, and may be freely movable.

The phenomena resulting from partial division of a nerve vary considerably. Certain groups of muscles are more liable to be affected than others supplied by the same nerve, and this is to be explained by the fact that there is a definite arrangement of the various bundles of fibrils in the nerve, and some portions of the nerves are more exposed to injury than others. Thus the fibres running in the great sciatic nerve to the external popliteal division are external to those constituting the internal popliteal division, and are thereby more liable to be injured. Details of the intratruncular arrangement of the fibres in different nerves must be sought in special works.

Partially divided nerves are sometimes the site of persistent and serious irritation, especially if a fragment of glass or metal remains embedded at the site of the lesion. Trophic phenomena, often of a grave character, may then supervene in the distal parts supplied by the nerve. The skin becomes thin, atrophic, bluish-red, and shiny ('glossy skin' of Weir Mitchell); the subcutaneous fat is absorbed; the hairs fall out; the nails become rough, brittle, and scaly; and the sebaceous sweat glands discharge an abundant secretion. The bones atrophy, joints become ankylosed, and ulcerative lesions occur on the slightest provocation.

In other instances, pain is the most marked feature, especially

in partial lesions of the median and sciatic nerves. The pain is of a burning character (*causalgia*), felt in the palm of the hand or sole of the foot, and brought on by touching the part, or by emotional stimuli, such as sudden noises. It is usually increased by even moderate degrees of heat or cold, and by any movements which drag on the nerve; it prevents sleep, and is very intractable. Its origin is somewhat doubtful, but it is possibly due to a spreading fibrosis of the nerve-trunk leading to compression of the nervi nervorum.

Wound infection adds a grave element to the damage caused by injuries to nerves. During the acute stage the exposed nerve-ends suffer equally with other tissues in the early destructive and later reparative processes necessary to combat infection. The development of scar tissue, moreover, introduces a barrier between the divided ends of the nerve. Bacteria and their toxins also gain access to the interior of the nerve, and travel up the interfibrillar spaces, perhaps for inches; reactive formation of connective tissue ensues, leading to fibrosis, which may extend for some distance and seriously hampers repair. The mere exposure of an undivided nerve in a suppurating wound is similarly liable to be followed by fibrosis. It is obvious that the sequelæ of nerve-lesions in gunshot wounds are liable to be of a graver character than those seen in civilian practice.

Regeneration of a divided nerve must necessarily precede restoration of function. Attempts at regeneration are always evident in the distal segment, whether or not it has been sutured to the upper end, but in the latter case the phenomena are never carried to perfection, owing to the intervention of the end-bulb. When this has been removed and effective end-to-end suture established, the axis cylinders of the proximal segment grow downwards and force their way along the sheath of the nerve, in which active preparations have been taking place, and from which the restoration of the varied elements of the sheath is determined. In any case, the process is slow and takes many months to reach completion. It is possible that under favourable circumstances an interval of half an inch or even more may be bridged by this process, but it is unusual. A nerve-graft may serve to direct the energies of the neuroblastic cells, but is probably quite passive. Clinically, the earliest evidence of regeneration is a slight return of sensation, which is at first protopathic, and only slowly becomes of an epicritic type. Motion is generally much later in its restoration than sensation, and may never be entirely recovered.

Treatment.—It is of the utmost importance that every divided nerve of sufficient size, especially if containing motor fibres, should be at once dealt with, if possible, by **Primary Nerve Suture.** This is best accomplished by using a domestic sewing needle without cutting edges, or a fine Hagedorn needle, and the finest catgut or linen (No. 160, Stiles); the nerve-ends should be brought into apposition without tension or torsion, and secured by sutures passing merely

through the sheath. Steadying stitches through the nerve are undesirable if they can be avoided. Absolute asepsis is essential in order to obtain satisfactory results. It is most desirable that the nerve should be protected from the pressure of adhesions by burying it in a bed of healthy muscle, or by wrapping around it a thin pad of fat or fascia. In wounds involving the nerves about the wrist the deep fascia should also be carefully sutured to prevent the formation of adhesions between the nerves and tendons to the skin, whereby subsequent mobility would be impaired.

It is often impossible to undertake nerve suture as a primary procedure, and operation for **Secondary Nerve Suture** at a later date is frequently found to be necessary. (1) It is as a rule useless to attempt suture in an infected wound, and inasmuch as organisms remain in a latent state in the scar tissue of such a lesion (p. 7) operation must be delayed for some months after healing has occurred. (2) In not a few cases it is difficult at first to make certain that a nerve has been actually divided, and that the loss of power, etc., is not due to concussion or partial laceration from which spontaneous recovery may be expected. Here again operation may be justifiably delayed.

The observer must not be deceived by *trick* or *substitute movements** brought about by muscles supplied by uninjured nerves. Thus after complete division of the median nerve in the forearm it is possible to oppose the thumb by joint action of the adductors (ulnar nerve) with the extensor ossis metacarpi pollicis (musculo-spiral). Flexion of the wrist after division of the median and ulnar nerves in the arm can be effected by the extensor ossis metacarpi pollicis It must also be remembered that the area of sensation supplied by a particular nerve is liable to great variations in different individuals.

Pre-operative treatment during the period of waiting is most important. (1) *Postural.*—The limb is placed on a splint or in a contrivance that will relax the paralyzed muscles and prevent them from becoming over-stretched. Thus, in a musculo-spiral lesion the hand must be kept in a position of hyper-extension at the wrist-joint (Fig. 91), in order to prevent wrist-drop. If the sciatic or external popliteal nerve is paralyzed, 'foot-drop' occurs, and a gaiter must be worn to prevent this by the use of springs or elastic tractors (p. 436). (2) During this time the joints of the limb—fingers toes, wrist, ankle, etc.—must be kept supple by daily *manipulation and movement* so as to prevent stiffness. The application of a splint for a long time without this precaution may result in extensive adhesions in joints and tendon sheaths, which will increase the trouble already present. (3) The tone of the paralyzed muscles must be maintained by *massage* and regular *electric treatment*. The galvanic current should be employed in the form of an electric bath, or the sinusoidal current may be used. The limb must also be kept warm by suitable coverings, as its circulation and nutrition are defective,

* See Wood-Jones, 'Orthopædic Surgery of Injuries,' Oxford, 1921.

and the limb must always be well warmed before either massage or electricity is applied.

The **operation,** though easy to describe, is one often performed with difficulty owing to the density of the scar tissue in which the ends of the nerve are buried. It is essential, therefore, to make extensive incisions in order to expose the nerve-trunk both above and below the lesion; the scar tissue is divided cleanly, and if possible removed, until the bulbous end above and the atrophied end below are freed. The bulb and fibrous junction are removed sufficiently to expose healthy nerve-fibres both above and below; it is desirable to test the lower end of the severed nerve by a weak faradic current. The ends are then stitched together as accurately as possible so as to appose similar portions of the nerve sections.

Some practical points may be noted which, if adopted, will enhance the success of the operation. (1) The nerve must be very gently handled; broad gauze strips passed under the nerve are more satisfactory than metal retractors. (2) The nerve must not be allowed to become chilled, but should be wrapped in gauze soaked in warm salt solution. (3) The question of *bridging an extensive gap* between the nerve-ends is one that is often difficult to settle. (*a*) There is a certain amount of extensibility of a nerve-trunk if it is completely freed for a considerable distance up and down. (*b*) Position of the limb is of great assistance—*e.g.*, flexion of the wrist, elbow, and knee; but it must be remembered that when dealing with the ulnar nerve above the elbow, flexion of the joint increases the tension; it is wiser under such circumstances to dislodge the nerve from its interval between the internal condyle of the humerus and the olecranon process, and bury it in the muscles in front of the condyle. (*c*) Bridging the gap by the union of flaps cut from the upper and lower ends; the lateral implantation of the divided ends into a healthy nerve; the interposition of a tube, such as a vein or of a nerve-graft, between the two ends in the hope that the axis cylinders may thereby be enabled to travel downwards—all these methods have been tried sufficiently often to demonstrate their inefficency. (*d*) The removal of a segment of the bone of the limb so as to shorten it permits of the accurate apposition of the nerve segments, but it is a serious addition to the operation, and should never be undertaken lightly. (*e*) Where all such procedures fail or do not commend themselves to the operator, the untrimmed ends of the nerve should be drawn as closely together as possible by stout tension stitches passed through them, and the limb placed in a relaxed position. After healing has occurred, the limb may be gradually straightened, the nerve being thereby stretched, and at a later date a second operation may succeed in securing coaptation of the trimmed ends.

In cases of incomplete division or compression of a nerve, it is sometimes difficult to decide on the appropriate treatment. A *lateral neuroma* should be dissected away, retaining carefully any nerve-fibres that appear to be healthy; the exposed surfaces are then drawn together by sutures so as to coapt the freshly divided

fibres, and the healthy ones are allowed to form a loop at the side (Fig. 128).

A *central neuroma* may similarly be dissected away after dividing the sheath by a free longitudinal incision, which permits the healthy nerve-fibres to be drawn aside unharmed.

The treatment of *causalgia* is one of great difficulty. No drugs appear to have any control over it except morphia; wet and cold applications to the hands or feet seem to be of some value. Injection with 80 per cent. alcohol may destroy the pain, but of course also destroys the function. If operation is undertaken, simple freeing of the nerve from the compression of scar tissue may suffice, but as a rule the sheath should be opened by a longitudinal incision and the interior of the nerve explored. If it is soft, and the function

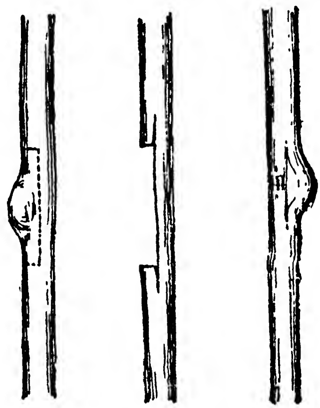


FIG. 128.—OPERATION FOR REMOVAL OF LATERAL NEUROMA FROM PARTIALLY DIVIDED NERVE.

of the nerve is moderately good, this should suffice; if it is hard, and the function of the nerve poor, excision and suture must be undertaken.

It is not fair to compare the *end-results* of these secondary operations with those of primary suture. The nerves are often embedded in scar tissue and are in a condition of fibrosis due to the infection of the original wound; the removal of these fibrous ends, together with the detachment necessary to permit of approximation, is liable to bring into contact two sections of the nerve of slightly different intratruncular pattern, so that quite apart from torsion it may result that motor axons find their way into sensory fibres or *vice versa;* indeed, when one considers the small size of the nerves to the smaller muscles of the hand or foot, it is wonderful that axis cylinders ever find their way correctly. Finally, the necessary delay always results in some degree of muscular degeneration or

fibrosis, and repair becomes increasingly difficult as time passes. The musculo-spiral nerve supplying large muscles with gross movements gives the best results; the sciatic and external popliteal nerves are fairly favourable, although the intrinsic muscles of the foot often fail to recover; the results of operations on the median and ulnar nerves are often disappointing, especially in the lower parts of the forearm, and complete restoration of function of the palmar muscles is uncommon.

Sensation of a general type may be restored quite early, but this often disappears again, and is only regained slowly after some interval; deep sensibility returns first, then protopathic sensation, and finally epicritic. Motor power is developed proximally at first, and gradually spreads downwards; at first all that may occur is a more brisk response to the galvanic current; voluntary movements often precede the appearance of faradic excitability. The trophic appearance of the limb and its general condition often improve considerably before any signs of movement appear. The date of recovery varies much, especially with the interval since the nerve was divided; the longer the interval, the later the restoration of function. It also depends upon the site of the injury, as obviously in lesions high up in the limb there is a larger segment of the nerve to be repaired. A musculo-spiral nerve may be expected to recover fully in six to eight months; a median or ulnar wounded and sutured above the elbow has done well if the movements are restored in six to twelve months; an external popliteal nerve may be restored completely in four to eight months after suture; but a great sciatic nerve, wounded high up in the thigh, takes probably two years to be repaired.

During all this time the precautions and treatment needed in the pre-operative period of the case must be maintained, and one can realize how bored the patients become, and how persistently patient and persevering must be the medical, massage, and electrical attendants. *The patient's will-power must be exercised to assist in driving nerve impulses across the gap and down the distal segment, and re-educational exercises must be employed as soon as some amount of volitional power has been regained.*

A useful sign of progressive regeneration of the nerve after operation is that described by Tinel,* although satisfactory repair can occur in its absence. On pressure or light percussion of the trunk a little distal to the site of the suture, a subjective sensation of tingling or stinging is experienced six or eight weeks after the operation, and as time passes it is possible to elicit this sign at a gradually lower level; it is due to the growth downwards of the new axis cylinders. Naturally in the musculo-spiral nerve, where there are few sensory fibres, it is not frequently elicited. It is advisable to employ this test from below upwards.

Finally, when all efforts to make good a divided nerve have failed, various tenoplastic procedures designed to counteract malpositions may be undertaken, or amputation may be required.

* Tinel, 'La Signe de "Fourmillement,"' *Presse Médicale*, October 7, 1915.

Acute Neuritis is not very common. It is sometimes due to injury, gout, or rheumatism, but is usually observed in connection with infected wounds. The nerve is swollen and becomes tender, whilst severe pain of a neuralgic type is often experienced. On microscopic examination the ordinary signs of inflammation are well marked, though mainly in the sheath. The **Treatment**, when not due to infection, consists of rest to the limb, together with leeching or dry-cupping over the course of the nerve, combined with belladonna fomentations and suitable general therapeutic measures.

Chronic Neuritis, or **Perineuritis,** is much more common than the former. It consists pathologically in an increase of all the connective tissue of a nerve, both around it and between the fasciculi, with compression of the vessels and nerve-fibres. It may result from injury, such as sprains, strains, or pressure, especially when the patient is suffering from syphilis, rheumatism, or gout, and is met with after influenza, and in various toxic conditions—*e.g.*, alcoholism, diabetes, malaria, etc. Apart from injury, neuritis is usually a manifestation of *fibrositis* (p. 462), and not unfrequently fibrous nodules can be detected on careful palpation, either involving or attached to nerve-sheaths; the extreme tenderness of many of these nodules also suggests the involvement of nerves. Highly sensitive spots are also found on the roots of the nerves, as they emerge from the spine, also where they pierce aponeuroses or deep fasciæ. The **Symptoms** vary a good deal with the nerve affected, which can occasionally be felt thickened and tender on pressure. More or less severe neuralgia results, accompanied by loss of power in the case of a motor or mixed nerve. Trophic lesions may also be induced, such as perforating ulcer, or ankylosis of the terminal joints of fingers or toes. The phenomena are usually much influenced by changes of weather.

Treatment is mainly directed towards removing the source of the trouble. All foci of toxic absorption are suitably dealt with, whether involving teeth, tonsils, nasal sinuses, appendix, or colon. Where operative measures are not indicated, vaccine treatment may be possible. Digestion must be improved, and the dietary modified to suit the individual requirements. Hydro-therapeutic measures should be instituted, whether at a spa or at home; in the latter case a small dose of saline purgative—*e.g.*, Epsom or Glauber salts, or a mixture of the same—should be taken each morning before breakfast in half a pint of warm water, and a tumbler of cold or hot water half an hour before each meal; no fluid is allowed at meals. Pain is combated by aspirin or similar drugs, but in bad cases morphia may be required at night. *Locally*, the affected part must be kept at rest until the pain and tenderness disappear, the arm, for example, being placed in a sling. Warmth of the affected area is an essential, and mild counter-irritation, as by the use of thermogene wool, is desirable. Massage in the early stages is as a rule injudicious, but gentle inunction with an iodine preparation, as, *e.g.*, iodex combined with methyl salicylate, is often helpful.

Electric baths are useful, the current passing from the limb, which is placed in a receiver containing a solution of bicarbonate or iodide of sodium or covered with a large pad of light soaked in the same, through the limb to a pad moistened with sodium chloride placed over the spine. As the condition improves, massage either alone or combined with hot douches (Vichy or Aix douche) is of great assistance. If there is any paresis, the muscles must be stimulated by the faradic current, and re-education exercises may be required.

For **Tumours** of nerves, see p. 219.

Affections of Special Nerves.

The Cranial Nerves.—The **Olfactory Nerve** may be involved in fractures extending across the cribriform plate of the ethmoid, or in severe cases of contusion of the anterior lobes of the brain without fracture, resulting in loss of smell (anosmia).

The **Optic Nerve** is sometimes ruptured in fractures of the base of the skull running into the optic foramen, or divided by penetrating or bullet wounds, leading to sudden irremediable blindness; or it may be compressed by effused blood or inflammatory exudation, either within or outside of its sheath, causing more or less complete loss of vision; if the hæmorrhage has not been very extensive, vision may be in measure restored. Orbital cellulitis not unfrequently causes pressure on the nerve, either immediately as a result of the inflammation, or subsequently by cicatricial contraction. Syphilitic disease of the sheath, or the formation of a gumma in its neighbourhood, or intra-orbital aneurisms or tumours, may likewise interfere with vision from pressure on the trunk. Optic neuritis, or more accurately acute papillœdema, is an œdematous condition of the intra-ocular termination of the nerve in the fundus oculi, due to increased tension of cerebro-spinal fluid; it is a frequent result of cerebral tumours or inflammation, and is generally followed by optic nerve atrophy and blindness.

The **Third Nerve** (*motor oculi*) being entirely motor, paralytic symptoms are those to be looked for. They may arise from *central* causes, such as syphilitic or degenerative changes in the floor of the third ventricle; or from *peripheral* lesions, such as aneurisms, tumours, gummata, trauma, etc., either in the orbit, sphenoidal fissure, or base of the skull. The **Symptoms** of complete paralysis are as follows: (*a*) Ptosis, or drooping of the upper eyelid, from loss of power in the levator palpebræ; (*b*) external strabismus, or squint, from paralysis of the inner, upper, and lower recti, the eye being also directed a little downwards from paralysis of the inferior oblique; (*c*) mydriasis, or dilatation of the pupil, from palsy of the iris; (*d*) loss of accommodation, from the ciliary muscle being paralyzed; and (*e*) some slight protrusion of the eyeball (exophthalmos), owing to most of its muscles being flaccid and relaxed. Diplopia is the most marked functional result. In consequence, however, of its close proximity to the fourth, fifth, and sixth nerves in the walls of the cavernous sinus and sphenoidal fissure, symptoms

referable to these trunks are often associated with the above, as also venous congestion of the eye and orbit from pressure on the sinus. Should the eyeball be totally immobilized from paralysis of all its muscles without venous congestion, the condition is known as 'ophthalmoplegia externa,' and is always due to central disease affecting the floor of the third ventricle, and probably of syphilitic or tabetic origin. The **Treatment** in most cases consists in the administration of mercury and iodide of potassium.

Paralysis of the **Fourth Nerve** (*Pathetic*), which supplies the superior oblique muscle, results in defective movement of the eyeball downwards and outwards, with diplopia on attempting to look down.

The **Fifth or Trigeminal Nerve** is occasionally torn in head injuries, giving rise to anæsthesia, with perhaps ulceration of the cornea; but such cases are exceedingly rare. Much more common is the affection known as *trigeminal neuralgia*, or tic-douloureux, which occurs in old people, particularly women. It is to be distinguished from the simpler forms of neuralgia due to some local irritation or general weakness by the paroxysmal character and violence of the pain; hence the term 'epileptiform tic' has been applied to it, and not inaptly represents its terrible nature. As a rule it commences in the infra-orbital or inferior dental branches, radiating thence to all the other divisions of the nerve. The paroxysms are not very frequent at first, but they increase both in number, duration, and severity, and may be induced by any peripheral stimulus, a sudden noise, a draught of air, etc., until at last the patient, utterly prostrate, either becomes a morphia habitué or may even attempt suicide. The condition is often influenced considerably by the general health, and intermissions of varying length occur. The attacks are accompanied by twitching of the muscles of the face, and even of the neck; also by unilateral sweating and hyperæmia of the head, which becomes so tender and hypersensitive that the patient cannot brush the hair or wash the face on the affected side. Lachrymation is a marked feature during the attacks, and the secretion of saliva or of nasal mucus may be increased.

The **Cause** is unknown; in a few cases tumours of an endotheliomatous character have been found involving the Gasserian ganglion, but in the great majority nothing abnormal can be found either in the ganglion or its branches.

In the **Treatment** of epileptiform tic all sources of reflex irritation should be relieved or treated, such as carious teeth, errors of refraction, intranasal trouble, ovaritis, etc. A word of warning is needed against the wholesale extraction of healthy teeth for this affection, which may, indeed, be aggravated rather than improved by such treatment. Various analgesic remedies, such as aspirin, antipyrin, phenacetin, croton-chloral hydrate, or menthol, will, of course, be employed, but morphia is often the only drug that gives relief. Exposure to cold and damp is undesirable, and residence in a warm

sunny climate may be beneficial. In cases that resist such treatment further measures may become essential, and formerly many grave operations, even involving removal of the Gasserian ganglion, were undertaken with moderately satisfactory results, but often with serious post-operative consequences, and with a decided death-rate. These have now been replaced by *Schlösser's* plan* of injecting the nerve-trunks, or even the ganglion itself, with alcohol (80 per cent.), which destroys the nerve-fibres and produces complete anæsthesia, with total relief of pain. If the neuralgia chiefly involves the infra-orbital nerve, that can be dealt with by excision in the first place; but a recurrence, which will probably be associated with pain in the third division, should be treated by injection of the ganglion through the foramen ovale. When the trouble is limited to the third division, that alone can be reached quite easily at the base of the skull and injected without attempting to deal with the ganglion in the first place.

Supra-orbital Neuralgia is usually distinct from epileptiform tic, and more amenable to therapeutic measures. The pain often recurs about the same time each day (hence the term *brow ague*), and may be treated by giving a pill containing ferri sulph. 1 grain, quininæ disulph. 2 grains, and morphin. hydrochlor. $\frac{1}{12}$ grain, four hours before the attack is expected, and repeating it every hour till six pills in all have been taken. Should the pain persist, neurectomy may be undertaken. The nerve emerges from the orbit through the supra-orbital notch, lying at the junction of the inner and middle thirds of the upper margin; it is reached by an incision following the course of the eyebrow, through which the orbicularis is divided along the line of its fibres. By incising the periosteum and depressing it, together with the orbital fat, the nerve can be followed back for some distance, and a considerable portion removed.

Infra-orbital Neuralgia, if not of the epileptiform variety, is usually the result of dental trouble or of mischief localized within the antrum (empyema or malignant disease), in the upper wall of which it is embedded. Fractures and injuries of the superior maxilla may lead to pressure on the nerve and consequent neuralgia from callus formation. Careful intranasal exploration and radiographic examination may throw light on the cause, and local treatment may suffice if a local cause can be detected. The nerve can be exposed by a horizontal or curved incision over its point of exit from the maxilla (*i.e.*, at a spot ½ inch below the centre of the infra-orbital border), and by removing the surrounding bone and depressing the mucous lining of the antrum the nerve can be followed back for some distance.

The *Inferior Dental Nerve* is sometimes the seat of neuralgia, due to compression in its bony canal as a result of dental troubles. It may then suffice to trephine the outer bony wall of the inferior maxilla, making the necessary incision along its lower border, and remove half its thickness, so as to expose the nerve in its canal.

The **Sixth Nerve** may be torn or compressed, either in its intracranial course along the inner wall of the cavernous sinus, or as it passes through the sphenoidal fissure, or in the orbit, as a result of penetrating wounds or blows. Its division causes paralysis of the external rectus and consequent internal strabismus.

The **Seventh or Facial Nerve** may be *paralyzed* from a great variety of causes, which may be described under the following headings:

* For details and methods of injecting the various branches of the fifth nerve, see Wilfrid Harris, 'Neuritis and Neuralgia,' Oxford Medical Publications, 1926.

(*a*) *Intracranial Lesions*.—If simply *cortical*, as from pressure, hæmorrhage, degeneration, etc., a limited portion of the opposite side of the face is usually involved. If *subcortical*, or in the corona radiata or corpus striatum, as from hæmorrhage, or softening due to carotid thrombosis or embolus, the paralysis appears on the opposite side, together with hemiplegia, but only the lower half of the face is affected, the associated movements of the eyelids being left. If the lesion is situated in the *pons*, the deep facial centres may be implicated, and then paralysis with rapid atrophy of the facial muscles ensues on the same side as the lesion, together with loss of power of the opposite arm and leg (crossed paralysis). If the *root* of the nerve between the centres and the internal auditory meatus is involved, the whole of the same side of the face is paralyzed, accompanied, as a rule, by deafness.

(*b*) *Cranial Lesions*.—There are two not uncommon causes grouped under this heading, viz., (i.) fracture of the base of the skull, involving the petrous bone, the paralysis supervening either immediately after the injury from laceration, a rare phenomenon, or some weeks later from implication in organizing blood-clot or callus, the usual cause; or (ii.) as a complication of chronic otorrhœa, due to compression or inflammation of the nerve in the aqueductus Fallopii, or its injury or division during a mastoid operation. In all these the palsy is complete on the side affected, and owing to the communication of the facial with the petrosal nerves in this part of its course, there may be unilateral drooping of the velum palati, the uvula being deflected towards the sound side.

(*c*) *Extracranial lesions* from injury, inflammation from exposure to cold, or the pressure of a tumour, *e.g.*, malignant disease of the parotid. This variety has been called 'Bell's palsy,' and is usually characterized by the whole side of the face being affected, but without implication of the palate or uvula.

The general **Signs** of facial paralysis (Fig. 129) are as follows: The side of the face is immobile and expressionless, all the natural folds and wrinkles being lost; the eye cannot be completely closed, and on attempting to do so the eyeball is usually seen to roll upwards and outwards; ulceration, and even perforation, of the cornea may result from this exposure. From the drooping and relaxation of the lower eyelid, the apposition of the punctum lachrymale to the conjunctiva is imperfect, and thus tears escape over the face (epiphora), a condition aggravated by the loss of the suction-like action of the lachrymal sac, owing to the associated paralysis of the tendo oculi and tensor tarsi. On attempting to move the face, as in laughing or showing the teeth, the muscles on the non-paralyzed side are alone contracted, and marked asymmetry results from the drawing over of the opposite side. The lips cannot be closed firmly, and hence whistling and such-like actions are prevented. Food collects between the cheek and the teeth, owing to paralysis of the buccinator, and the patient after a meal has to clear out the débris with a spoon or his fingers.

The **Treatment** of facial paralysis should, if possible, be directed to its cause. Accidental division of its extracranial portion must be followed by suture, either immediate or secondary. When due to the pressure of a tumour, it may be possible to free it by operation. In cases caused by cold, medical treatment, including massage and electricity, must be relied on, and will usually prove effective. When the paralysis persists, and especially if due to some cranial lesions which cannot be reached, **nerve-anastomosis** may be undertaken, one-half of the hypoglossal nerve being united to the divided peripheral end of the facial nerve. The results hitherto obtained have been very encouraging; facial movements slowly return, but are

FIG. 129.—RIGHT FACIAL NERVE PARALYSIS.
Note absence of wrinkles on the right side of the face.

first elicited by and accompanied with movement of the tongue; in time, however, they become more independent, but are rarely quite free. However, the operation gives a certain amount of muscular power, and may remove the facial asymmetry.

Facial Tic (or histrionic spasm) consists of a clonic contraction of the facial muscles, due to an irritative lesion in the cortex or pons, or the reflex result of some affection of the nasal mucous membrane or of the teeth. The condition causes great discomfort to the patient, and may involve the whole side of the face, or merely one part of it, such as the orbicularis oculi. **Treatment** consists in the administration of nerve tonics or antispasmodics, and in the removal of sources of reflex irritation. The only operative procedure of any value is the injection with alcohol of the nerve at the stylomastoid foramen.

Operation.—The facial nerve can be exposed immediately below the ear, its position being indicated by a horizontal line drawn from the middle of the anterior border of the mastoid process, and usually corresponding to the point where the mastoid meets the lobule of the ear. The incision extends from just behind the external meatus along the anterior border of the sterno-mastoid muscle to the level of the angle of the jaw. The parotid gland is separated from the muscle, and both are well retracted, exposing by this means the posterior belly of the digastric. The facial nerve is found above this, running directly forwards from the centre of the mastoid process. The great auricular nerve is divided in the superficial incision, and the posterior auricular vessels will require a ligature. The internal jugular vein is close to the posterior margin of the wound. The operation is a deep one, and by no means easy in a patient with a thick neck.

The **Auditory Nerve** may be injured in fractures of the base of the skull, either one or both sides being involved. Incurable deafness usually results, often associated with facial palsy.

It is a little doubtful what effect would be produced by injury of the **Glosso-pharyngeal Nerve,** but in one case in which it was supposed to be compressed the patient suffered from difficulty in swallowing and speaking, together with persistent ulceration of the tongue; death resulted from œdema of the glottis.

A severe crushing injury to the **Pneumogastric Nerve** may prove rapidly fatal from heart failure or pulmonary congestion, but less serious lesions result in palpitation, vomiting, and a sense of suffocation; such phenomena sometimes manifest themselves after head injuries, especially fractures involving the posterior fossa, and indicate that the jugular foramen has been encroached on. The nerve is also exposed to injury in operations about the neck, *e.g.*, ligature of the carotid, or removal of tuberculous or malignant glands. Irritation causes vomiting, coughing, or perhaps a temporary inihibition of the heart's action; one-sided division sometimes does comparatively little immediate harm, but if both nerves are divided, death results from laryngeal paralysis or from such complications as œdema or congestion of the lungs.

The effect on the larynx of these lesions is described elsewhere, but one may note here that in the *early* stages compression-paralysis of the recurrent laryngeal nerve, as by an aneurism, affects the abductor muscle (crico-arytenoideus posticus), the result being that the cord involved is approximated to the middle line, and then the voice is not impaired, although dyspnœa is present. At a *later* stage compression-paralysis corresponds to the phenomena produced by complete section of the nerve, as in an operation for goitre, viz., the cord lies in the cadaveric position, *i.e.*, half-way between its position in phonation and deep inspiration; in this, breathing is unimpaired, but the voice is husky.

The **Spinal Accessory Nerve** may be irritated, either at its exit from the skull by a fracture running through the jugular foramen, or in its peripheral course by inflamed lymphatic glands, etc. It is occasionally divided in operations for the removal of tuberculous or malignant glands, and in children this may cause serious deformity

from tilting of the scapula (p. 489), especially if the branches of the cervical plexus supplying the trapezius are also severed. Clonic spasm of the sterno-mastoid and trapezius is generally due to central changes, and for this form of spasmodic torticollis stretching or division of the spinal accessory nerve has been employed, but is of little or no value.

Operation.—The nerve runs downwards and backwards at right angles to the centre of a line passing from the angle of the jaw to the apex of the mastoid process; it enters the deep aspect of the sterno-mastoid about 3 inches below that spot. An incision is made along the anterior border of the sterno-mastoid, reaching from the ear to the cornu of the hyoid bone. The fascia is divided, and the muscle drawn backwards to expose the posterior belly of the digastric, from under the lower border of which the nerve emerges, passing first in front of and then below the transverse process of the atlas, which can be readily felt.

The **Hypoglossal Nerve** may be accidentally divided in an operation for the removal of tuberculous or cancerous glands, or it may be compressed by an aneurism of the external carotid, or invaded

FIG. 130.—TONGUE IN PARALYSIS OF RIGHT HYPOGLOSSAL NERVE.

by a new growth. It is also affected to a certain extent in some forms of hemiplegia. Unilateral paralysis or weakness of the tongue results (Fig. 130), the organ, when protruded, being directed towards the paralyzed side.

The Spinal Nerves.

The nerves constituting the **Cervical Plexus** are exposed to injury either from blows, dislocations of the cervical spine, penetrating wounds, or during operations. No very serious results follow, except in the case of the **Phrenic Nerve,** bilateral division of which may cause instant death by paralysis of the diaphragm. Unilateral avulsion from the neck has been employed as a therapeutic agent in order to paralyze one half of the diaphragm, and thereby secure rest to the lung in cases of bronchiectasis or tuberculous disease affecting the lower lobe. It has proved distinctly beneficial in some cases. Irritation of the nerve gives rise to spasmodic cough or hiccough.

The **Brachial Plexus** may be injured in gunshot wounds, or occasionally divided by *cuts or stabs* in the lower part of the posterior

triangle, and the accident will be characterized by the motor or sensory phenomena corresponding to the particular nerves involved; the lower nerve-trunks are more often involved than the upper.

Tears or contusions of the plexus, a more common accident, may be complete or partial, and result from injuries in which the arm is dragged suddenly upwards, as when in falling a person clutches at some projecting body, or from forcible depression of the shoulder in a fall whilst the head is driven towards the opposite side, the nerve-roots being thereby wrenched from their attachments, or the nerve-trunks compressed by the clavicle against the first rib. Long-continued hyper-extension and abduction of the arm, as during an operation in the Trendelenburg position, also cause undue traction upon the roots of the plexus, especially of the fifth and sixth nerves. A fracture of the clavicle by direct violence may result in injury of the plexus, and the pressure of a cervical rib may affect the ~~inner~~ cord. Dislocation of the head of the humerus into the axilla, or the attempts to reduce it, may also be responsible for injuries, especially to the inner cord. The lesions consist either of a complete rupture of the nerve-trunks, or of a partial rupture with hæmorrhage into and around the sheaths. If the sheaths remain untorn, repair is usually established after a time; but where a complete laceration has occurred, much cicatricial tissue is likely to form, and unless operation is undertaken, repair is improbable.

In infants a *brachial birth-palsy* is observed, due to forcible stretching and tearing of the roots of the plexus. It is caused by overstretching of the head during delivery, and may occur equally in vertex or breech presentations; it is usually unilateral, and affects more frequently the left arm. At first supraclavicular tenderness may be noted, and then the loss of power of the arm becomes manifest; this may affect the whole arm to begin with, but with suitable treatment the condition usually limits itself either to the upper arm or Erb-Duchenne type (80 per cent.), or to the lower arm or Klumpke type (20 per cent.).

Symptoms.—If all the **nerve-roots** are involved, the whole arm is paralyzed, and lies flaccid and anæsthetic by the patient's side. Sensation is alone present down the inner side of the arm as far as the elbow (intercosto-humeral nerve), and for a more limited portion on the outer side. Paralysis often involves the pectoralis and scapular muscles, but the rhomboids and serratus magnus retain their nerve-supply. Oculo-pupillary changes may be manifested if sympathetic fibres are involved in the injury; the pupil is contracted, and mydriasis defective on excluding the light.

The **upper-arm type** is generally due to tearing or stretching of the fifth and sixth cervical nerves, and corresponds to what is known as the *Erb-Duchenne paralysis*. There is loss of power of the deltoid, spinati, biceps, brachialis anticus, and supinator longus muscles, as well as of the clavicular fibres of the pectoralis major, the latissimus dorsi, teres major, rhomboids, and subscapularis. Sensation is usually but little involved, as the area supplied by the fifth and

sixth roots is not extensive (Figs. 136 and 137). The result on the limb is very characteristic. The arm lies close to the side and cannot be abducted or rotated, but in children fixed internal rotation may become evident later on. The forearm is extended and in a position of pronation, all supination being lost, and the elbow cannot be flexed. Usually the movements of the hand and wrist are unimpaired, but occasionally the wrist extensors are paretic.

The **lower-arm type** is caused by injuries to the eighth cervical and first dorsal nerves, the resulting paralysis being described as of the *Klumpke type*. The flexors of the wrist and fingers (Cviii) and the intrinsic muscles of the hand (Di) are paralyzed, and a claw-hand (Fig. 135) results. Anæsthesia along the distribution of the ulnar nerve becomes evident.

Lesions of the cords of the brachial plexus below the clavicle are uncommon, and it is unnecessary to describe their effects, which are controlled by their well-known anatomical distribution.

Treatment necessarily varies with the situation and degree of injury, but follows that for lesions of the peripheral nerves.

Aseptic cuts and stabs are of course explored, and divided nerves secured, if possible, by primary suture.

In infected lesions, such as the majority of gunshot wounds, suture must be delayed until the infection has disappeared and the wound healed, and in the meantime massage and electricity are employed to maintain the nutrition of the muscles.

Obvious causes of pressure, such as the depressed fragments of a broken clavicle, or the callus resulting therefrom, must be removed, and a cervical rib, if causing symptoms, should be excised.

In traumatic cases without open wound, and this includes the birth-palsies, the arm is placed at right angles to the trunk and kept at rest, whilst local pain and tenderness are relieved by fomentations. The position is important in that it limits tension on the nerve-ends and approximates them as much as possible. After a short while passive movements are employed to keep the joints supple, and massage and galvanism are commenced to maintain the tone of the muscles. Power and sensation gradually reappear in those regions where the nerve-supply has not been severed, but the paralysis persists in the muscles supplied by the divided nerves, and the reaction of degeneration appears in due course; a thickened cicatricial mass can usually be felt at the site of the lesion. Under these circumstances operation is desirable in order to secure the restoration of continuity of the injured nerve-trunks.

The brachial plexus is exposed through an incision running downwards along the posterior border of the sterno-mastoid and prolonged downwards, if need be, across the clavicle. The scalenus anticus is defined, and the nerves are found emerging from between it and the scalenus medius; cicatricial tissue is removed, and the nerve-ends are freshened and sutured together. In cases involving the lower section of the plexus, it may be necessary to divide the

clavicle in order to expose the affected portion of the nerves. The results of operations of this type have been on the whole encouraging, if they are not delayed too long. In neglected cases of birth-palsy of the Erb-Duchenne type it is sometimes necessary to free the shoulder-joint, which has become fixed; division of the tendon of the subscapularis is then useful so as to permit the arm to be raised from the side.

Occasionally, the injury is more limited, as when a blow on the back of the neck leads to paralysis of the serratus magnus and rhomboids, and to the subsequent development of a 'winged scapula'; it may also result from cold or toxæmia (p. 489).

The **Circumflex Nerve** is liable to injury from its exposed position, winding round the outer side of the neck of the humerus about a finger's breadth above the middle of the deltoid. Blows upon the shoulder may in this way cause paralysis; it is sometimes torn or compressed in fractures of the surgical neck of the humerus, or in dislocation of the shoulder, or it may be impacted in the callus arising from the former injury. It is involved more often in crutch palsy. Paralysis of the deltoid and teres minor follows, evidenced by inability to raise the arm from the side, whilst the wasting of the former muscle causes undue prominence of the acromion. There may be temporary anæsthesia over the posterior fold of the axilla, but this does not last long. **Treatment.**—If the cause of the pressure is removed, massage and electricity are usually sufficient to determine restoration of function, and operative measures are seldom required. It must be remembered that in the early stages of re-educational exercises, the weight of the arm must be eliminated by supporting it on a table (p. 303).

The **Musculo-spiral Nerve** may be injured in fractures and dislocations of the upper end of the humerus, but is more likely to be damaged in fractures involving the musculo-spiral groove. It is implicated with or without other nerves in crutch palsy, or by lying asleep with the arm across the edge of a chair or table, as sometimes occurs in drunken people ('Saturday-night paralysis'). It is not unknown after operations when the outstretched arm has rested on the edge of the table, or when the Trendelenburg position has been adopted and the arms have been kept above the patient's head, the upper end of the humerus pressing against the brachial plexus. In this position the arms should not be raised to more than a right angle with the trunk.

Total division of the nerve causes the following symptoms:

A. Anæsthesia. If the nerve is divided in the upper third of the arm—*i.e.*, above the origin of its external cutaneous branch—there is loss of both epicritic and protopathic sensation over the radial half of the dorsum of the hand, of the epicritic a little more than of the protopathic. Section of the radial nerve in the upper third of the

forearm causes no loss of sensation, which is supplied to the back of the hand by the external cutaneous of the brachial plexus; but section in the lower third causes a limited loss of epicritic sense over the back of the thumb.

B. Paralysis of the following groups of muscles:

(i.) Of the extensor of the forearm (triceps); hence the forearm can only be extended by its own weight.

(ii.) Of the long and short supinators; hence the hand is pronated, the only supinator remaining being the biceps.

(iii.) Of the radial and ulnar extensors of the wrist; hence wrist-drop (Fig. 131), a condition also present in certain lesions of toxic or central origin, *e.g.*, lead palsy.

(iv.) Of the extensors of the fingers and thumb, which either hang limp and motionless, or may be bent up into the palm from the unopposed action of the flexor muscles. If, however, the wrist and proximal phalanges are supported and extended, the terminal phalanges can be straightened by the action of the interossei and lumbricales.

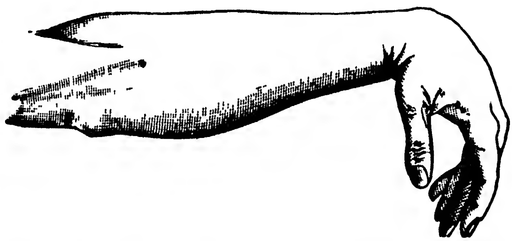


FIG. 131.—WRIST-DROP FROM PARALYSIS OF THE MUSCULO-SPIRAL NERVE.

Treatment.—In all cases of paralysis of the musculo-spiral nerve, the first essential is to prevent stretching of the muscles and tendons on the extensor aspect of the wrist by fixing the hand in a position of slight hyper-extension by the use of a 'cock-up' splint (Fig. 91). The forearm is massaged and the muscles treated by electricity, whilst the question whether or not an operation is required is being considered, or whilst the wound, if septic, is being treated and healed. When once it is decided, however, that the nerve has been divided as indicated by absence of improvement, the sooner operative treatment is undertaken the better. For general details, see p. 416. Where the nerve is impacted in the callus arising from a fracture of the middle of the shaft of the humerus, it is often best to expose it by a median incision down the back of the arm, splitting the triceps, the centre of the wound being opposite the insertion of the deltoid. Where there is much loss of substance, the nerve must be freed widely above and below so as to increase the chance of approximating the ends; in a few cases a portion of the humerus

has been excised in order to shorten the limb sufficiently. The prognosis of this operation is on the whole good.

In cases where operation has failed, or where the posterior interosseous nerve has been gravely damaged and cannot be repaired by operation, the condition of wrist-drop may be improved by grafting the tendons of the flexor carpi ulnaris and the flexor carpi radialis into the tendons of the extensors of the thumb and fingers, and the detached tendon of the pronator radii teres into the lower ends of the divided radial extensors of the carpus. A longitudinal incision along the radial border of the middle of the forearm suffices for the latter operation; a horseshoe-shaped incision with the convexity downwards, reaching to the back of the carpus, and with the straight sides over the radial and ulnar borders of the forearm, is required for the former. The wrist can by this means be kept in a position of slight hyperextension without interfering with the movements of the thumb and fingers.

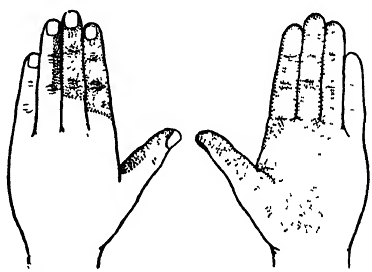


FIG. 132.—DIVISION OF MEDIAN NERVE ABOVE THE WRIST.

The shaded parts indicate the area over which epicritic sensation is lost.

The **Median Nerve** may be damaged in fractures and dislocations of the humerus, but in civilian practice is most frequently injured just above the wrist by glass wounds, due either to bursting of bottles, etc., or to thrusting the hand and arm through a window. Gunshot wounds of the *forearm*, above or below the elbow, are frequently associated with it, and compound fractures of the humerus, radius, or ulna may accompany this lesion.

Paralysis, more or less complete, results from these injuries, and is not unfrequently associated with severe causalgia referred to the palmar surface of the hand. The symptoms are tolerably characteristic.

If divided just above the wrist:

A. Anæsthesia. Loss of epicritic sensation over the palmar aspect of the radial side of the hand, as well as of the thumb, index, middle, and half the ring fingers, and over varying portions of the dorsum of the same (Fig. 132); loss of protopathic sensation, including analgesia to pin-pricks over a much more limited portion, varying considerably in different cases with the area of distribution of the terminal branches of the external cutaneous and ulnar nerves (Fig. 126).

B. (i.) Paralysis of the outer group of the short muscles of the thumb (*i.e.*, abductor, opponens, and outer half of the flexor brevis pollicis), so that the thenar eminence

wastes, and the movement of 'opposition' is impaired, the thumb remaining extended by the side of the fingers (Duchenne's 'ape-hand').

(ii.) Paralysis of the outer two lumbrical muscles, causing loss of power of flexion at the metacarpo-phalangeal joints of the index and middle fingers.

(iii.) Occasionally there is some irregularity in the nerve-supply of the interossei, the abductor indicis in particular not unfrequently receiving nerve impulses from the median; paralysis of this muscle is therefore sometimes present in lesions of the median nerve.

The great impairment of mobility in the hand and fingers so often seen in these patients depends not so much on paralysis of muscles as on the fact that in the majority of cases the tendons at the wrist or the muscle bellies in the forearm are matted together in scar-tissue, or buried in dense adhesions resulting from diffuse septic inflammation. The delay that often precedes such operations also allows adhesions to form in the joints and tendon sheaths of the fingers, which are thereby stiffened; this trouble is of course aggravated when infection is present, the adhesions often becoming so diffuse and dense as to bring to naught the attempt to restore function by a secondary operation (p. 416).

If divided at the bend of the elbow or in the arm, to the above-described symptoms are added:

(i.) Loss of pronation from paralysis of the two pronators.

(ii.) Paralysis of the flexor carpi radialis, causing defective wrist flexion on the radial side and impaired radial abduction.

(iii.) Paralysis of the flexor longus pollicis, of the flexor sublimis, and the outer half of the flexor profundus digitorum, leading to loss of power in the hand-grasp, especially on the radial side, and perhaps hyper-extension of the wrist.

(iv.) Paralysis of the palmaris longus.

Operative treatment on the median nerve is carried out in accordance with the general rules indicated elsewhere, and not unfrequently the nerve is simply bound down in a dense scar-tissue, and merely requires to be freed from this and protected by a pad of fat or buried in muscle. In cases where it has been divided, the scar-tissue must be removed and the ends sutured. This is rendered possible in cases where there is much loss of substance by flexing the wrist and bending the elbow.

The prognosis of operations on the median nerve is not very satisfactory (p. 419). In successful cases the median flexor group in the forearm may be expected to recover in from six to eight months, whilst the intrinsic muscles of the hand do not show evidence of recovery until after the expiration of twelve months.

The **Ulnar Nerve** is exposed to injury at the wrist, as also in the hollow between the olecranon and the inner condyle of the humerus,

and paralysis may be caused by penetrating or gunshot wounds, fractures, blows, implication in callus, etc. Undue exposure of the nerve just above the elbow, either as an anatomical abnormality or as a result of cubitus valgus, renders it liable to injury and to mild attacks of neuritis, and may require to be treated by its transplantation to the front of the condyle.

The symptoms of division of the nerve are very characteristic.

If divided at the elbow:

A. Analgesia or loss of protopathic sensation of the little finger and ulnar border of the palm, back and front, seldom of the ring finger; anæsthesia to light touch (loss of epicritic sensation) of the ulnar side of the front of the wrist and palm, of the back of the hand, and of the little and half the ring fingers, back and front (Figs. 133 and 134).

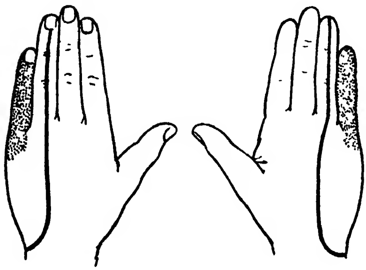


FIG. 133

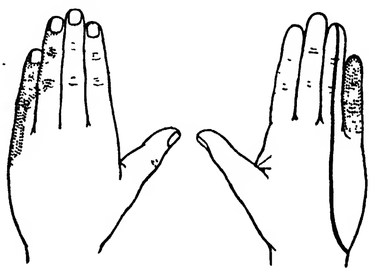


FIG. 134

ANÆSTHESIA RESULTING FROM DIVISION OF ULNAR NERVE.

In Fig. 133 the nerve was divided above the origin of the dorsal branch; in Fig. 134 below that branch close to the wrist. The continuous dark line indicates the limits of the loss of epicritic sensation; the shaded area shows the loss of protopathic sensation.

B. (i.) Paralysis of the flexor carpi ulnaris, causing weakness in flexion and in ulnar adduction of the wrist.

(ii.) Paralysis of the inner half of the flexor profundus, with weakened hand-grasp, especially in the ring and little fingers.

(iii.) Paralysis of the two inner lumbricales and of all the interossei; hence, loss of adduction and abduction of the fingers, with flexion of the two last phalanges in each finger and hyper-extension at the metacarpo-phalangeal joint (*main-en-griffe*) or claw-hand (Fig. 135). The interosseous spaces also become very evident from atrophy of these muscles.

(iv.) Paralysis of the short muscles of the little finger, of the inner group of short thumb muscles (adductor transversus, adductor obliquus, and deep portion of flexor brevis), and of the palmaris brevis.

If *divided just above the wrist,* the anæsthesia only involves the palmar aspect of the hand and back of the terminal phalanges (Fig. 134), whilst the paralysis merely affects the short palmar muscles. Additional impairment of movement may, however, arise from septic inflammation of the long tendons and their sheaths.

Treatment.—The nerve, when divided, must be dealt with (according to the rules already given) at the injured spot. It is often difficult to bridge the gap between the two ends, but this is assisted by *bending* the wrist to a right angle. When dealing with the nerve in the neighbourhood of the elbow, flexion of this joint increases the tension on the nerve, owing to its situation behind the internal condyle. It is then desirable to displace the nerve from this position, and bring it into the forearm in front of the condyle, burying it in the muscles.

The prognosis of ulnar nerve operations is unfavourable as those of the median, and for a similar reason. In both cases tendon-transplantation is of little value, since the tendons are frequently embedded in dense scar-tissue. 26-9.40.

The **Intercostal Nerves** are frequently the seat of severe neuralgia, either from chronic neuritis, probably of toxic origin, from compression by tumours or inflammatory lesions of the ribs, or from injury or pressure directed to the nerve-roots as they emerge from the spine, as in spinal caries (girdle-pain). Herpes zoster or shingles is sometimes associated with such pain, and may be followed by some amount of anæsthesia

FIG. 135.—CLAW-HAND (MAIN-EN-GRIFFE) FROM ULNAR PARALYSIS.

The **Twelfth Dorsal Nerve** is not unfrequently the seat of neuralgia of a somewhat severe type, following its distribution to the anterior abdominal wall and buttock, and occasionally leading to a mistaken diagnosis of some abdominal lesion—*e.g.*, appendicitis or chronic ovaritis—and not a few operations have been unnecessarily undertaken in consequence. In some cases it is caused by the undue projection of the tip of the last rib, which becomes injured and inflamed, the nerve becoming adherent thereto; removal of the rib or its tip suffices to cure the patient. In not a few cases of operations on the kidney the nerve becomes entangled in the scar, and this is a source of most troublesome pain, the only cure of which is to cut down, free the nerve, and pull out its central end.

The **Great Sciatic Nerve** is frequently involved in injuries resulting in temporary or permanent paralysis as the outcome of penetrating

or gunshot wounds; in ordinary civilian surgery it is an uncommon accident. The injury is usually situated below the gluteal fold, and inasmuch as the hamstring muscles receive their branches above this level, the resulting paralysis is usually similar in type to that caused by a lesion of the external or internal popliteal nerves (more frequently of the former), or of both. If, however, the nerve is damaged near its exit from the pelvis, the hamstring muscles participate in the paralysis. If only a small section of the nerve is damaged in a gunshot wound, severe pain (causalgia) may be experienced in the sole of the foot, and is a distressing and intractable condition during the period of waiting until operation is undertaken. The muscles of the limb must be kept in as good condition as possible by massage and electricity, and deformity of the foot prevented by wearing a suitable support to prevent foot-drop.*

Operation.—The nerve is exposed in the back of the thigh by a suitable incision, which in the upper part of the thigh should pass to the outer side of the biceps muscle so as to avoid muscular branches. In the lower part of the thigh it may pass to the inner side of this muscle. If the nerve has been injured not far from the pelvis, it is perhaps better to divide the gluteus maximus close to its attachment to the great trochanter and lift that muscle upwards rather than to divide the muscular fibres in the line of the nerve. A suitably curved incision will be required for this purpose. When the nerve is laid bare, it is freed from scar-tissue so as to expose the nerve-fibres. The surgeon need be in no great fear of being unable to bridge the gap if the knee is fully flexed. Every effort must be made to suture the ends of the nerve accurately, so that the external and internal popliteal segments may be correctly apposed. The knee is kept flexed for about ten days, and then may be gently and gradually extended. The after-treatment is prolonged, and if the patient has regained power in the course of nine to twelve months, he has done well.

In cases where the paralysis persists in spite of operation on the nerve, improvement in the gait may be secured by the use of a suitable hinged knee splint, and by arthrodesis of the ankle or tendon fixation (p. 470). Under no circumstances should amputation through the thigh be undertaken, except possibly for persisting pain; in a few cases where the foot is badly nourished and ulcerated, a Syme's amputation is admissible and gives good results.

Sciatica, or neuralgia of the great sciatic nerve, is a most painful affection, and often exceedingly intractable. It may arise from the

* *Colam's gaiter for foot-drop* is a very suitable contrivance. It consists of a felt gaiter, laced up the front from below upwards and tied at the upper end. The cord used for lacing is then carried over in front of the gaiter, and tied to a motor spring. At the lower end of the spring is a blunt double hook, which is introduced under the lowest portion of the bootlace. The foot is by this means kept in a good position, and the apparatus is easily worn under the trouser.

following **Causes:** (*a*) Inflammation of the neurilemma (acute or chronic fibrositis), the result of cold, injury, gout, rheumatism, syphilis, and many toxic agents; (*b*) pressure upon the extrapelvic portion of the nerve, as by aneurisms, tumours, or old-standing dislocations of the head of the femur on the dorsum ilii; (*c*) similar pressure upon the nerve in the pelvis, or as it emerges through the sacro-sciatic notch, as from sarcoma or osteoma of the pelvic bones, rectal or uterine cancer, a pregnant uterus, or uterine fibroids; (*d*) pressure upon the nerve-roots in the spinal canal, as from caries or sarcoma; (*e*) chronic diseases of the spinal cord, such as tabes.

The **Symptoms** are very characteristic, the pain shooting down the back of the thigh, and being often referred to the toes. It is of a paroxysmal nature, and may be brought on by pressure over almost any part of the nerve or by movements of the thigh, and hence the patient's gait is stiff and shambling. Tenderness in the line of the nerve is felt when the cause is a peripheral neuritis, and the trunk may sometimes be detected on palpation as a thickened cord. The limb is usually kept slightly bent, but complete flexion of the thigh on the pelvis is an impossibility; and if, when the patient is standing against a wall, the limb can be raised to a right angle with the knee extended, it is certain that sciatica is not present. Inspection of the buttocks in a case of genuine sciatic neuritis reveals a loss of the gluteal fold and marked flattening of the nates on the affected side, causing noticeable asymmetry. Careful examination of the patient's pelvis must always be made before determining that a case is 'merely sciatica.'

The **Treatment** necessarily varies with the cause. If due to neuritis or perineuritis, general anti-syphilitic or anti-rheumatic measures may be adopted, and blisters or sedative remedies in the more acute cases applied to the back of the thigh. Hypodermic injections of morphia may be required at night, and the nerve itself may be injected with saline solution. Injections into the nerve of 1 c.c. of the following solution once or twice a week for three weeks will often do substantial good: phenazonum, ʒii.; cocain. hydrochlor., gr. ii.; aqua destillata, ʒii.ss. Failing such measures, *stretching of the nerve* may be employed, and not unfrequently excellent results follow. It may be accomplished without operation by flexing the thigh upon the abdomen and then extending the knee; in cases of sciatica an anæsthetic will be required for this, but it may be attempted before undertaking operative procedures.

The nerve is best *exposed* for stretching at the point where it emerges from under cover of the gluteus maximus, midway between the tuber ischii and the great trochanter. The patient lies in the prone position with the limb slightly flexed, and a 4 or 5 inch incision is made vertically downwards from the gluteal fold in the middle line of the thigh The lower border of the gluteus maximus is first exposed, and its fibres are seen running downwards and outwards. The hamstring muscles emerging from under it are drawn inwards, and the nerve is

found ensheathed in loose connective tissue; it is stretched, by a finger hooked under it, both peripherally and proximally, using a considerable degree of force, which must be applied steadily and continuously, not in jerks. The effect is to cause some loss of conductivity for a time by breaking up the medullary substance; external adhesions are snapped, and a beneficial hyperæmia is induced, whereby toxic material is eliminated.

The **External Popliteal Nerve** may be divided during a subcutaneous tenotomy of the biceps, to which it lies immediately internal; or compressed, as it winds round the neck of the fibula, by strapping, bandages, or splints; or it may be injured in fractures of the neck of the fibula. It is frequently injured in gunshot wounds—three times as often as the internal popliteal nerve. Total division causes anæsthesia of the dorsum of the foot, and of a varying portion of the front and outer side of the leg, together with paralysis of the extensor and peroneal groups of muscles. In the earlier stages, inability to dorsiflex the foot results in a condition of 'drop-foot,' but later on the contraction of the unbalanced opposing groups results in the paralytic form of talipes equino-varus. The nerve may be exposed by making an incision $1\frac{1}{2}$ inches long to the inner side of the biceps tendon, terminating at the neck of the fibula, or just below the neck of that bone. See also on Treatment of Paralytic Talipes Equinus (p. 511).

The **Internal Popliteal Nerve** is much less exposed to injury owing to its more sheltered position. Division results in loss of epicritic and protopathic sensation over the sole of the foot, and of epicritic sensation for the plantar surface of all the toes and for the dorsal aspect of the outer four; also in paralysis of the calf muscles, flexors of the foot and toes, and of the short muscles of the sole. Paralytic talipes calcaneo-valgus is very likely to ensue. The nerve is laid bare by a vertical incision in the middle of the popliteal space, which should avoid the short saphena vein. After division of the deep fascia, the nerve is the most superficial structure.

If the **Tibial Nerves** are divided, the resulting effects are more limited; thus, paralysis of the extensors of the foot and paralytic talipes equinus result from division of the anterior tibial; and paralysis of the short and long flexors of the foot and of the interossei, with resulting talipes calcaneo-valgus, follow lesions of the posterior tibial. The nerves may be exposed in the same way as the accompanying arteries (p. 378).

The **Sympathetic Nerve-trunk** in the neck is occasionally compressed by aneurisms or tumours. If merely irritated, dilatation of the pupil on the same side and unilateral sweating of the head and face are produced; but, if divided, the pupil is contracted from unbalanced action of the third nerve.

The Nerve-Roots.

It is a well-known fact that during the development of the embryo the primitive spinal cord, which was originally co-terminous with the trunk and with the vertebral column, gradually lags behind in its growth, so that at birth and subsequently it does not extend down the canal further than the lower border of the first lumbar vertebra. This necessarily involves a displacement of the attachment of the spinal nerves upwards, so that these points of origin of the nerves do not correspond to the intervertebral foramina, and a variable length of the nerve exists within the canal formed at first by the junction of the anterior or motor ramus with the ganglionated posterior or sensory ramus. In the cervical region each spinal segment is about one vertebra above its corresponding body; in the upper dorsal region this interval amounts nearly to two vertebræ; whilst all the spinal segments corresponding to the lumbar, sacral, and coccygeal nerves are crowded between the tenth dorsal and the first lumbar vertebræ.

The nerve-roots after this downward intraspinal course pass through the intervertebral foramina, where they are exposed to injury and pressure, and after various divisions and combinations constitute the peripheral nerves. It must be remembered that almost all the peripheral nerve-trunks are derived from a number of nerve-roots, and the complex distribution of these has been carefully worked out. It follows that the distribution of sensation over the trunk according to the nerve-roots is a very different thing to that of the peripheral nerves, and the practitioner and student must carefully study the diagrams appended (Figs. 136 and 137) in order to familiarize themselves with this arrangement. Particularly noticeable is the amount of overlapping of sensory areas, a provision whereby defective sensation due to localized injuries may be minimized. Sherrington has shown that in apes cutaneous anæsthesia will not result from the division of any two consecutive posterior nerve-roots, but only when three are divided; this has been confirmed in man. The control of muscles or groups of muscles is similarly distributed over two or three consecutive nerve-roots, presumably with a similar object; whilst the nerve-fibres from muscles, tendons, ligaments, etc., upon which the muscular tone and control of the limbs so much depends, also enter the cord by several nerve-roots.

Pressure on the nerve-roots may be caused by tumours of the spine or spinal cord, by tuberculous or gummatous lesions, or by callus or adhesions forming about the intervertebral foramina. Intense neuralgia is the most prominent symptom, together with hyperæsthesia; this, it will be noted, always follows the nerve-root areas, and not those of the peripheral nerves. Herpes zoster may be induced by the affection, and in time anæsthesia may follow.

Similar symptoms may arise from slight displacements of the vertebræ and partial fractures; but even these are usually of

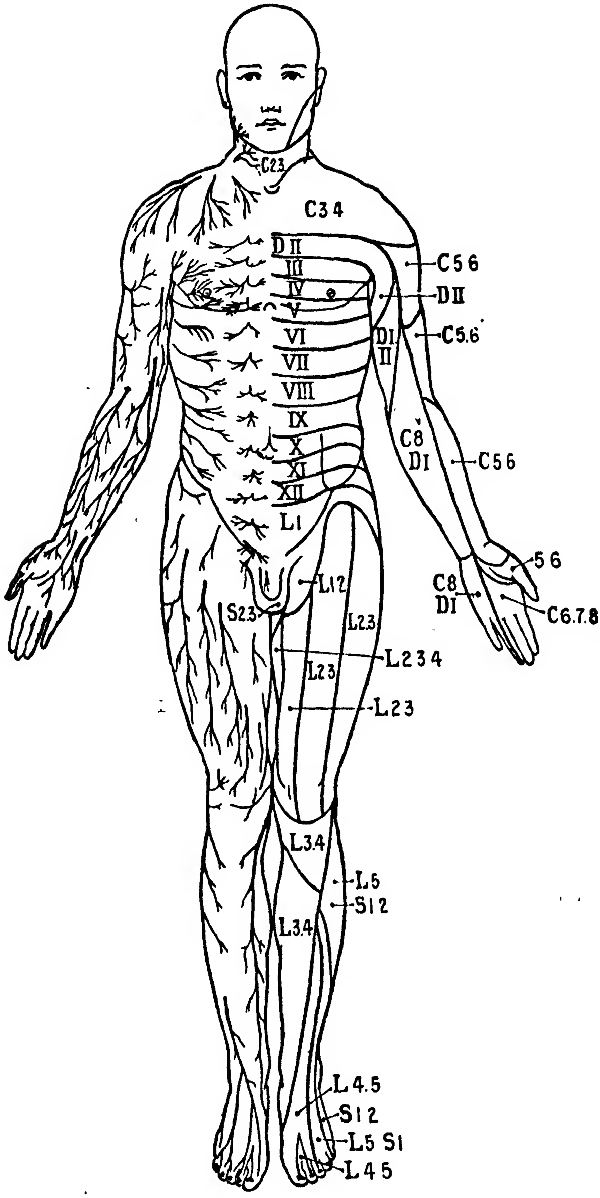


FIG. 136.—NERVE-ROOT AREAS: ANTERIOR ASPECT OF TRUNK.

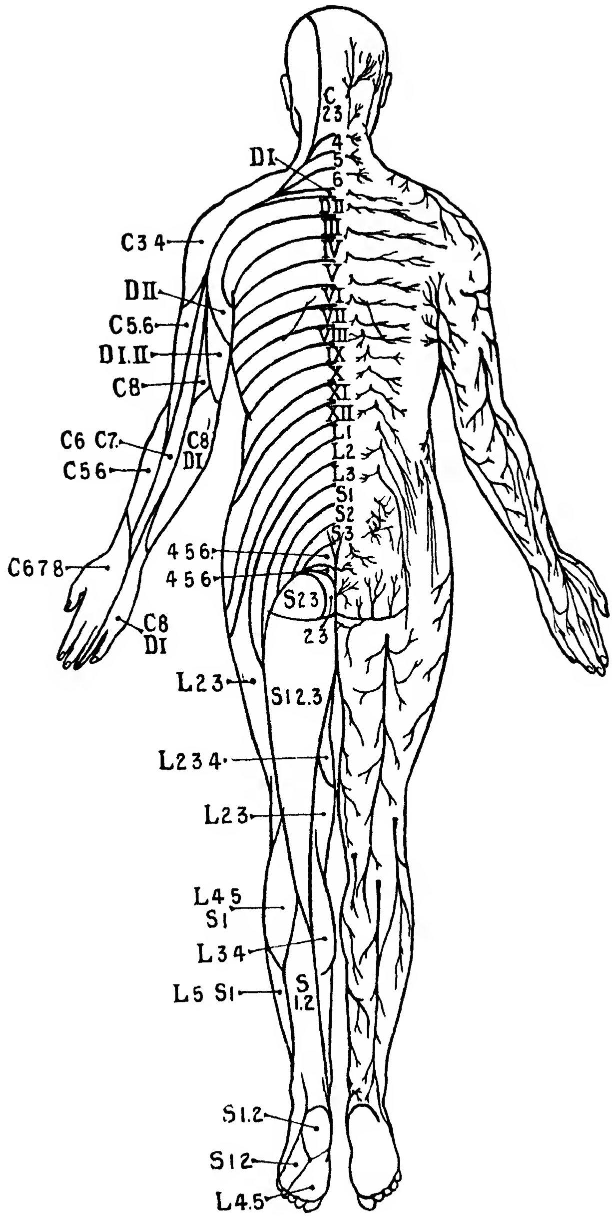


FIG. 137.—NERVE-ROOT AREAS: POSTERIOR ASPECT.

a complicated nature, and involve considerable ligamentous lesions; they can only be diagnosed with certainty by the most careful radiography, and may give rise to nerve-root symptoms. The peripheral phenomena are governed by the anatomical distribution of the nerves, and certain well-defined and localized manifestations, mainly of the neuralgic or paretic type, correspond to each nerve-root involved. This statement is no justification for the claim that visceral diseases generally are due to slight unrecognized displacements of the spine, which can be cured years later by manipulation of the affected vertebra, and that usually without any anæsthetic.

Chordotomy has now completely replaced Förster's operation, or division of the posterior roots. It consists of the division of the antero-lateral (spinothalamic) tracts in the spinal cord at a level above the entrance of the nerve-roots from the affected part. The operation is indicated for the following conditions:

(1) Intractable neuralgia, due either to irremovable pressure or to an ascending neuritis, where medical methods are of no avail.

(2) For severe cases of gastric crises and the lightning pains of tabes dorsalis.

(3) In certain cases of very painful osteoarthritis of the hip.*

* A. S. Blundell Bankart, *Lancet*, vol. ii., 1929, p. 378.

CHAPTER XVII.

SURGICAL DISEASES OF THE SKIN AND OF THE CUTANEOUS APPENDAGES.

A **Boil or Furuncle** is a localized inflammation of the skin, usually terminating in suppuration, due to infection with staphylococci of a hair follicle or sebaceous gland. Experimentally, a plentiful crop of boils can be produced by rubbing a culture of staphylococci into the skin, and clinically a similar infection is the most common cause of this condition. The secondary or satellite boils which form around a primary one are due to the friction upon the healthy integument of dressings, covered with pus and microbes.

People with coarse skins and a tendency to comedones are specially liable to the occurrence of boils, but some depressing constitutional condition, such as chronic Bright's disease or diabetes, is often present in patients who suffer from recurrent crops of boils. A gangrenous inflammation ensues after infection, resulting in the death of the hair follicle, or of the sweat or sebaceous gland involved, and of the surrounding connective tissue, and the slough thus formed is cast off by a process of suppuration. A matured or ripe boil, therefore, consists of a central slough or core, a zone of pus around it, and external to this granulation tissue merging into healthy skin and connective tissue.

Signs.—A boil commences as a small red irritable pimple, from which a hair may often be seen to protrude; it increases gradually in size, becoming more and more painful, until it forms a conical tumour, deep red in colour and exquisitely tender. A small whitish spot appears in the centre, and around this so-called core yellow pus can be seen. Finally it bursts, discharging the pus, and subsequently the core or slough comes away. The process is then at an end, and the wound rapidly heals by granulation. Occasionally the inflammation extends more deeply into the subcutaneous tissues, constituting a 'carbuncular boil.' Lymphangitis sometimes follows, and the neighbouring lymphatic glands may become sympathetically enlarged and painful, but rarely suppurate. A boil sometimes subsides without suppuration, leaving the parts thickened and infiltrated, the condition then being known as a 'blind boil.'

Treatment.—Many boils may be left to burst naturally, though possibly the process may be checked by painting them twice daily with iodine (2 per cent.) and applying Klapp's suction-glass two or three times a day. Where pus has formed, an incision is made, and the suction-ball persisted in till the slough has come away. In the later stages the skin around should be thoroughly purified, and the pus and core received on portions of wool soaked in carbolic lotion (1 in 20), and the cavity lightly swabbed out with pure carbolic acid. A small collodion dressing is then applied. Tonics, such as iron and quinine, are usually required, except in plethoric individuals, in whom a spare diet and abstinence from stimulants may be recommended. A change of air to a bracing seaside place is often advisable, especially when a succession of boils has appeared. In the more persistent cases a staphylococcal vaccine may be employed with advantage, and the boils will in some cases be cured or aborted (p. 25). In others the vaccine seems to do but little good, and then stannoxyl may be employed, or injections of collosol manganese (½ to 2 c.c.) every three or four days; excellent results have been reported in many cases, but it is not infallible.

A Carbuncle is a more extensive infective gangrene of the subcutaneous tissues, due to a local invasion with pyogenic microbes, the commonest being the *Staphylococcus pyogenes aureus*. It occurs in individuals run down by any general debilitating condition, such as albuminuria or diabetes, in whom the germicidal powers of the tissues are much depreciated; it is also occasionally met with as a sequela of acute fevers. The exciting cause may be some blow or squeeze, resulting in extravasation of blood or some local diminution of vitality; into this area cocci are implanted either by auto-infection, or more usually through the sweat-glands or hair follicles, or through some slight superficial abrasion.

Signs.—A carbuncle commences as a hard, painful infiltration of the subcutaneous tissues, the skin over which becomes red and dusky. The swelling gradually increases in size in all directions, until a diameter of many inches may be reached. As it extends peripherally, the central parts, which were formerly brawny, become soft and boggy, and the overlying skin shows evidences of yielding to the pressure within. Vesicles form on the surface, and finally pustules; these in turn burst, and allow a tardy exit to the ashy-gray sloughs and purulent discharge accumulated below. Fresh openings gradually develop, leading to a cribriform condition of the cutis; some of these apertures enlarge and run into one another, producing a central irregular crateriform opening, at the bottom of which lies the necrotic tissue. As the violence of the inflammation subsides, the sloughs gradually separate, leaving a clean granulating wound Carbuncles most frequently occur on the back, the nape of the neck, the shoulders, and nates, where the vitality of the tissues is never very active; when they form on more vascular parts, such as the face and lips, the consequences may be even more serious, since infective thrombosis of the large veins may follow, and this may

quickly spread up to the cavernous sinus. The soft and spongy tissue of the cheek is a very favourable place for the extension of the necrotic process, and there may be a wide area of mischief under an apparently insignificant superficial lesion. A carbuncle is usually single, and may be accompanied by lymphangitis and a painful enlargement of the nearest lymphatic glands.

There is often considerable constitutional disturbance of an asthenic type, although the temperature is not necessarily much raised. A temporary glycosuria of toxic origin is sometimes present, and disappears as the condition improves, but occasionally pyæmia or septicæmia may supervene.

Treatment.—In the early stages Bier's treatment by induced hyperæmia may be successful in preventing suppuration, but where the organisms are at all virulent or the focus large it will probably fail. Attention should always be directed to the possible presence of co-existing disease. A thorough physical examination is made with a view to finding any debilitating condition contributing to the lowered resistance of the patient. The heart, lungs, and alimentary tract should receive careful attention; the urine should always be tested, particularly for sugar, acetone, and albumin. Local relief is obtained to some extent by applying a hot fomentation over a dressing of perchloride of mercury 1 : 4,000, and by keeping the part at rest as far as possible.

Operative treatment should aim at the total excision of the carbuncle. An incision is made through the whole length of the diseased area, cutting to the limit of its depth; a second incision is made through its breadth, crossing the first at a right angle in the centre of the carbuncle. The points of the four flaps so defined are cut with sharp scissors near their base, and as much as possible of the necrotic tissue is dissected away. The remaining débris is then cleared away from the centre of the cavity; a sharp spoon is best for this purpose. Hæmorrhage may be considerable at this stage, but it may be controlled by firm pressure and packing with gauze. The base and the walls of the cavity are lightly touched with a pledget of wool soaked in pure carbolic acid. The cauterizing effect of the acid is shown by the manner in which it arrests oozing from the cut vessels; it also has the merit of destroying any active organisms which may have survived curetting with the knife or spoon. It has been observed, however, that it sometimes increases the amount of subsequent sloughing. The cavity is packed tightly with cyanide gauze, care being taken not to invert what remains of the flaps. An abundant dressing of sterile gauze and soft wool is applied, and the operation completed by a tight bandage, which should be ample enough to immobilize the affected part. Good food, iron, and quinine must be administered, whilst appropriate treatment by insulin and limitation of diet are necessary in diabetic patients.

A **Corn** (*clavus*) is a localized outgrowth of the epidermic layer of the skin, together with a central ingrowth of a hard, horny plug,

which compresses and causes atrophy of the underlying papillæ, constituting a cup-shaped hollow, whilst the surrounding papillæ are hypertrophied. The presence of this central plug constitutes the difference between a true corn and a simple callosity or diffuse overgrowth of the epidermis. Any abnormal pressure is capable of producing either condition, granting that it is not sufficiently severe or intense to lead to ulceration; but corns seldom occur except on feet, and the chief cause is badly-fitting boots. Two varieties are described—viz., the hard and the soft.

The **hard corn** usually occurs on the little toe, or over the head of the metatarsal bone of the great toe, or over the heads of the first phalanges of the other toes, especially if there is any tendency to hammer-toe. They form more or less conical swellings, with a dark, dry, central plug, and are often very painful, especially when rain is threatening. Suppuration sometimes occurs beneath a corn, and the pain then becomes acute. If it is not attended to early, the pus may burrow and cause necrosis of deeper parts or a destructive arthritis. **Treatment** consists in paring the corn, after softening with hot water, or treating with salicylic acid plaster (10 or 20 per cent.), or painting with a solution of salicylic acid in collodion. A ring of felt plaster may subsequently be worn, but attention must be directed to the boots, and the cause of the trouble removed. Occasionally, where the toe is deformed, or disease of the bones or joints has developed, it is necessary to perform amputation.

A **soft corn** occurs between the toes, and owing to the absorption of sweat the surface looks white and sodden; it is often extremely painful. **Treatment** consists in removing the thickened cuticle after the use of salicylic acid. The parts are very carefully cleansed night and morning, and spirit of camphor painted on at night, whilst cotton-wool is worn between the toes during the day. Failing this, the corn must be removed by operation. The toes are held widely apart, and the incisions run transversely between them, so as to include the corn. The wound can be readily closed by sutures.

Perforating Ulcer of the Foot forms on some part of the sole, and progresses deeply so as to involve sooner or later the bones and joints. It is usually due to two main factors, viz., *anæsthesia* of the sole, and more or less persistent *traumatism*, such as arises from wearing a tight boot or from the presence of a nail, which is not noticed owing to the concurrent anæsthesia. It is therefore likely to be met with: (1) In certain central nervous diseases—*e.g.*, tabes dorsalis, syringomyelia, spina bifida, etc.; (2) in diseases such as diabetes, syphilis, alcoholism, etc., which lead to peripheral neuritis; and (3) as a sequence of traumatic lesions of the nerves affecting any portion of their course from the spinal cord downwards. (4) Perforating ulcer is occasionally due to pure plantar lesions, apart from any nervous influence, *e.g.* a suppurating wart or corn, or even a chronic epithelioma. The skin under the head of the first metatarsal is the part most frequently affected, but any spot to

which undue pressure is directed may become involved, and not uncommonly several such sores may be seen on the same foot. A corn or callosity first forms, and under this a bursa, in which suppuration takes place; the pus, finding a difficulty in coming to the surface owing to the thickness of the cuticle, spreads deeply into the soft structures of the sole, and the suppuration may even involve bones and joints. A typical perforating ulcer presents the appearance of a sinus passing down to the deeper parts of the foot, and even extending through to the dorsum; the orifice is surrounded by heaped-up and thickened cuticle (Fig. 138). There is sometimes but little discharge and often no pain, but when bones or joints are affected, free suppuration may occur. If allowed to progress without treatment, the bones and joints of the foot may be destroyed extensively, or may be welded together into a solid painful mass,

FIG. 138.—PERFORATING ULCER OF GREAT-TOE, PENETRATING TO BONES AND CAUSING NECROSIS.

The scar of an old healed ulcer of similar type is seen on the outer side of the foot.

in either case necessitating amputation. A cure can sometimes be determined in the early stages by removing the thickened mass of cuticle and purifying or excising the sinus; the cavity thereby formed is packed with gauze and allowed to heal by granulation. Periarterial sympathectomy is useful in many cases, but should it fail, or if bones or joints are involved, amputation will be required.

A **Wart** (*verruca*) is a papillary overgrowth of the skin, appearing as a horny projection about the size of a split pea, and usually seen on the hands of young people; its surface may be smooth or irregularly filiform, and its colour varies with the amount of dirt ingrained on the surface. When smooth-topped, they are sometimes extremely numerous, and may be a little difficult to dis-

tinguish from lichen planus. In parts where there is a certain amount of moisture warts become soft in character, and form large vascular masses—*e.g.*, venereal warts. The best method of treating ordinary warts is to paint them with glacial acetic acid, or some other caustic, every two or three days, after softening and removing the horny crust with salicylic acid. Ionic treatment with salicylates is also of value.

Verruca Necrogenica (see p. 266).

A **Chilblain** (*pernio*) is an inflammatory hyperæmia, usually involving the fingers, toes, or ears, and determined by exposure to cold. It is generally seen in young people with defective circulation, whose fingers and toes easily 'go dead.' They are very apt to occur on paralyzed limbs. After the period of anæmia and pallor, the part begins to itch or burn, and becomes red, swollen and shiny. Exudation occurs into and beneath the skin, and in bad cases a blister with blood-stained contents forms; when this bursts, troublesome ulceration ensues. To prevent the formation of chilblains the patient's circulation must be improved, and exposed parts kept warm. A course of lactate of calcium is helpful; 5 grains, t.d.s., are administered the first week, 10 grains during the second week, and 15 grains during the third, followed by a suitable tonic. In the earlier stages treatment by induced hyperæmia is most valuable; an elastic bandage may be worn for six hours or so daily, whilst locally the parts may be painted with tincture of iodine or a solution of ichthyol. When the chilblain breaks, simple antiseptic precautions may suffice, but a more stimulating application is usually required, and Peruvian balsam or resin ointment will be found useful. In paralyzed limbs, or cases otherwise intractable, galvanic baths will usually prevent the development of these troublesome lesions.

Tuberculous Affections of the Skin.—Lupus Vulgaris is a chronic inflammation of the skin of tuberculous origin. It is met with in children and young adults, rarely commencing after the age of thirty. Its most usual situation is the face, generally starting on the nose or cheek (Figs. 139 and 140). It is rare on the scalp, but fairly common on the trunk and extremities. The mucous membrane of the nose and mouth is also attacked, but usually by extension from the skin. It is not often symmetrical, except when commencing on the nose.

Clinical Features.—The earliest manifestation of lupus consists in the formation of one or more shot-like nodules in the deeper layers of the skin, which are surrounded by a zone of hyperæmia and infiltration. These nodules are not particularly hard to the touch, but when of any size can be demonstrated to be of a brownish-orange tint, especially if they are devascularized by the pressure of a glass slide, and then the colour somewhat resembles that of apple-jelly. Gradually the process extends, and usually more rapidly in one special direction, following the course of the vessels. At the same time the integument becomes infiltrated and transformed into

granulation or cicatricial tissue, covered by a layer or two of epithelium (Fig. 139), and owing either to degeneration of the tuberculous nodules, or to a lack of vitality, arising from compression of the vessels by the contraction of this new formation, ulceration is very liable to follow (Fig. 140). In the extremities the lupoid growth not infrequently takes on a warty aspect, somewhat similar to the 'anatomical wart' occasionally seen on the knuckles of post-mortem porters (p. 266).

A *Lupoid Ulcer* usually spreads at one margin as it heals at the other, and hence under typical circumstances is more or less crescentic in shape. The surface is covered with granulations, often of a protuberant nature. The edges are raised and infiltrated, and scattered lupoid tubercles are readily distinguishable extending into the healthy tissues, which are usually red and congested. A considerable amount of sero-pus is often secreted, and this by drying forms thick scabs. Any cicatrix which results from natural processes of cure is thin and vascular, easily breaking down from slight irritation. The process extends gradually, with or without inter-

Fig. 139.—Non-ulcerating Lupus of Cheek.

Fig. 140.—Ulcerating Lupus of Nose and Cheek.

missions, from the seat of its first appearance; it is as a rule limited to the cutaneous tissues, but when it attacks the nose, the cartilages are often involved and destroyed, whilst if it involves the palate or septum nasi, perforation is very likely to follow. The disease is almost painless, and does not at first affect the general health. Neighbouring lymphatic glands may become inflamed, and in a few instances are the seat of a tuberculous deposit. Left to itself, it usually comes to an end sooner or later, the ulcerated parts cicatrizing, but leaving indelible traces of its ravages in the shape of obvious scars, with often considerable loss of substance. Occasionally it persists in spite of treatment, and then an epithelioma may in time develop on the site of the mischief, running a rapid course owing to the vascularity of the part.

Pathological Anatomy.—The characteristic microscopical feature of lupus lies in the formation of nodules around the smaller vessels of the skin, consisting chiefly of a mass of round cells, within which may perhaps be observed a giant cell and endothelioid cells, arranged in the same way as in tubercle. The structures around are infiltrated and hyperæmic; as the disease progresses, the original tissue of the part disappears, and is replaced by granulation or fibro-cicatricial tissue. The bacilli are by no means readily found, and are always few in number.

The **Diagnosis** of lupus from syphilitic and other destructive affections of the skin turns on the presence of outlying nodules beyond the spreading edge of the lesion, together with the apple-jelly-like granulations, and the thin, congested character of any cicatricial tissue present, whilst the slow, though continuous, progress, and the tendency to heal at one part as it spreads at another, are also suggestive of its presence. The age and constitution of the individual, the absence of the Wassermann reaction, and the persistence of the disease in spite of treatment, must also be taken into account.

In the **Treatment** of lupus reliance is now placed almost entirely on *heliotherapy* (p. 309), both local and general, or on exposure to the ultra-violet rays of a *carbon-arc light*. The *Finsen light* (p. 308) similarly has curative powers. In the latter each sitting lasts for one and a quarter hours, and an attendant whose eyes are shielded by dark glasses controls the crystal water-chamber, keeping it firmly against the skin, and slightly shifting it from time to time, so that an area as large as a shilling may be acted upon at each séance. Slight inflammatory phenomena follow, and a local leucocytosis supervenes, as a result of which the disease disappears and a soft supple scar is produced, which is often very little obvious. This type of treatment has been found of most value where ulceration is absent and the patch of no great size. *X-ray treatment* plays its part in the treatment of lupus. The same precautions as to the protection of healthy tissues must be taken as for cancer (p. 314). The best results have been observed by using a tube of comparatively low vacuum, and by working for a definite inflammatory reaction; when this has disappeared, the treatment is repeated. The length of the course necessarily varies, but as a rule three to six exposures a week of not more than ten minutes each will suffice. The X rays act best on the ulcerative and fungating forms of lupus, which clear up and heal; but after this has been secured, their action must cease, partly because they have no influence upon the small nodules of disease which remain entangled in the scar-tissue, and also because their prolonged action might terminate in the appearance of epithelioma. For these nodules the Finsen or arc light treatment should be employed.

When treatment of this type cannot be obtained, or where in spite of improvement nodules of the lupoid material persist, the lesions may be dealt with by scraping with a lupus spoon, and subsequently applying solid nitrate of silver, acid nitrate of mercury

on a match-end, chloride of zinc as a paste, solid powdered permanganate of potash, or even the actual cautery. A pointed diathermic cautery is also useful for digging out and destroying localized lupus nodules. Certain drugs may also be used to cause necrosis of the nodules in the diseased tissue, of which the best is pyrogallol, applied in a 10 per cent. ointment (Whitfield). x 9-10-40.

Lupus Erythematosus is a disease the nature of which is not yet satisfactorily determined. The appearance of the affection is tolerably characteristic; it is usually situated on the face, and in the most typical cases symmetrical patches are formed over the root of the nose and cheeks, corresponding in appearance to a butterfly with outspread wings. The condition frequently invades the forehead, ears, and scalp, and occasionally appears on the trunk, being then unilateral. It appears as a smooth hyperæmic surface, covered with a branny desquamation; the scales consist of inspissated sebum, and are continuous with deep plugs, which can be traced into the mouths of enlarged sebaceous follicles. As the disease spreads peripherally, the older and central portions are transformed into cicatricial tissue of a pale, thin and white type, in marked contrast to the hyperæmic condition of the advancing margin. It is usually seen in adults, and more frequently in women than men. Progress is exceedingly slow, and ulceration uncommon except when the ears or scalp are involved; in the latter region the hair is often lost. Epithelioma has also been known to follow this affection.

The **Treatment** consists in attention to the general health, together with the local application of weak tarry and mercurial preparations. The X rays and Finsen light act rapidly, but must be used with caution, since the inflammatory disturbance caused by them is considerable.

Affections of the Nails.

A **Paronychia** (panaritium, or 'run around') is a condition frequently seen in surgeons, nurses, or others who have to expose their hands to infective material, as a result of infection of the semilunar fold at the base of a nail. It is often preceded by a 'hang-nail,' which gives entrance to the organisms, and the patient's general condition may be unsatisfactory; not uncommonly, however, it is seen in hospital nurses and others who have just returned from a holiday, suggesting that they need to become immunized to their surroundings. The skin at the side of the nail is swollen and hyperæmic, and on pressure is tender to the touch; gradually the pain increases and is particularly troublesome at night, perhaps preventing sleep. A certain amount of discharge may occur through the semilunar fold, but a sufficient exit is rarely given by natural processes. Unless effective treatment is undertaken, the suppuration spreads around the root of the nail to the other side, and also burrows beneath the nail, separating it from the matrix. Granulations spring up freely from the semilunar fold, and thereby discharge is often prevented from escaping.

Treatment in the early stages is by fomentations and the induction of passive hyperæmia by the application of Martin's bandage to the arm; the skin at the side of the nail is pared down, and if pus appears, an incision parallel to the basal margin of the nail through the inflamed tissues will give exit to the pus, and often suffices to cure the case. If the pus has burrowed beneath the nail, one or more incisions must be made radially through the semilunar fold

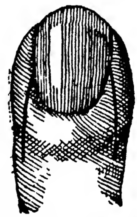


FIG. 141.—INCISIONS FOR TREATMENT OF PARONYCHIA.

(Fig. 141), so as to expose the base of the nail, and permit all the loosened portion to be cut away from the matrix by sharp scissors; in some cases all the base of the nail has thus to be sacrificed. The terminal portion may, however, be left, as it is serviceable while the new nail is forming. Abundant granulations spring up from the matrix, and these may need to be kept in check by nitrate of silver.

Ingrowing Toenail is an ulcerated condition of the soft parts projecting over the side of one of the toenails (usually that of the great-toe), and due either to the pressure of pointed or badly-fitting boots, or to neglect in trimming the nails. The fold of skin is thus pressed by the boot over and against the nail when the patient walks, and in order to diminish the pain and irritation caused thereby, he often cuts away the projecting angle of the nail, but leaves a deep corner, which still further irritates the soft parts. Ulceration ensues, accompanied by an offensive discharge and so much pain as to prevent

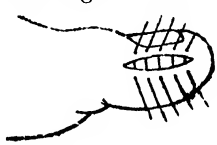


FIG. 142.—OPERATION FOR INGROWING TOENAIL.

the patient from walking. The matrix of the nail may also become inflamed, and onychia result. In the earliest stages, further progress can often be prevented by careful attention to the nails, by the use of square-toed boots fitting easily, and by introducing small plugs of aseptic wool to press back the overhanging fold of skin. A cure can sometimes be effected by excising an oval portion of skin from the side of the toe and close to the nail. The edges of the incision are drawn together by horsehair, and thus the overgrowing fold of skin is drawn away from the nail (Fig. 142). It is more satisfactory,

however, to excise the overhanging fold of skin completely so as to expose the side of the nail, which can also be cut away, if necessary, together with the projecting angle. This latter treatment must always be adopted when ulceration and suppuration are present.

The term **Onychogryphosis** is applied to a hypertrophic condition of the nails, which become distorted and bent, or twisted up, perhaps simulating a ram's horn. It is usually limited to the great toes of elderly people, and is due to neglect. The nails are very rough, and often covered with grooves or ridges, whilst beneath them is an accumulation of soft, offensive epithelium. The only treatment is removal.

Affections of the Sebaceous Glands.

Sebaceous Cysts occur on any part of the surface of the body, but especially the scalp, and are due to obstruction of the duct of a sebaceous gland. They are rounded swellings, firm and elastic to the touch, movable on the deeper structures, and always attached at one spot to the skin. On careful examination, the obstructed mouth of a sebaceous follicle can usually be seen, and possibly some of the contents of the sac squeezed through this opening. The cyst wall is formed by several layers of epithelium, surrounded by dense fibro-cicatricial tissue, and if exposed to irritation or pressure, as when situated on the back or shoulder, and rubbed by the braces, becomes very firmly adherent to the surrounding parts. The material contained within is of a cheesy, pultaceous consistency, with a peculiar stale odour, yellowish-white in colour, and under the microscope is seen to be composed of fatty and granular débris, epithelial cells, and cholesterine. Left to themselves, the cysts may attain considerable dimensions, whilst the walls and contents sometimes become calcified. Occasionally the exudation oozes through the duct, and dries on the surface, with just sufficient cohesion to prevent it from falling off; layer after layer of this desiccated material is deposited from below, finally giving rise to what is known as a **Sebaceous Horn.** These become dark in colour from admixture with dirt, and are always more or less fibrillated in texture; the base, to which they are firmly adherent, is infiltrated and hyperæmic. Sebaceous cysts sometimes inflame and suppurate; sooner or later they burst or are opened, and then the process subsides. They may be cured in this way, but more frequently the cyst fills up again, and the same series of phenomena are repeated after an interval. Should the contents only escape partially, the remainder is liable to undergo putrefactive changes, giving rise to an offensive ulcerated surface with raised edges, which may readily be mistaken for epithelioma. It is sometimes known as *Cock's Peculiar Tumour.* True malignant disease of an epitheliomatous nature is said occasionally to supervene.

Diagnosis.—From a *dermoid cyst* it is known by the facts that the dermoid is congenital in origin, that it is limited to certain localities, whilst it is hardly ever directly attached to the skin. From a *fatty*

tumour it is recognized by its rounded shape, its fixity to the skin, the absence of lobulation, and by its more solid character, whilst a lipoma is softer and more movable. From a *chronic abscess* it is distinguished by the dilated orifice, by its firmer consistency, and by the history.

Treatment.—A sebaceous cyst should be entirely and completely removed if giving rise to any disfigurement, inconvenience, or pain. In the scalp all that is needed is to transfix the tumour, squeeze out the cheesy contents, and then the cyst wall can be readily removed by grasping it with dissecting forceps and pulling it away. In other situations the cyst wall may require to be dissected out; but even then it is advisable to open it by transfixion, and to deal with the sac from within. Horns and fungating ulcers should be excised with the surrounding skin.

Occasionally a true **sebaceous adenoma** develops in connection with these cysts. It may be slowly-growing and of a firm, solid consistency; but sometimes it is much more vascular and grows rapidly. The latter has a form of semi-malignancy in that it is very liable to recurrence, and has therefore often been mistaken for a sarcoma. On microscopic section it closely resembles a rodent ulcer, but its clinical history is quite distinct. Its most frequent situation is the scalp, and it requires to be removed with a free hand, the defect in the scalp being made good by Thiersch-grafting.

Molluscum Contagiosum.—This affection shows itself in the form of a number of firm hemispherical nodules, a little larger than a split pea, usually of a yellowish-white colour, and very definitely umbilicated. The depression in the centre may be occupied by dry débris, and from the larger ones a waxy mass can be expressed. They are usually seen on the face, but may involve any part of the surface of the body. There seems no doubt as to their contagious properties, this being perhaps best seen in the development of growths of this nature on a mother's breast, secondary to those on the face of her baby, but the cause of the contagion is by no means certain. Pathologically, the tumours consist of numerous wedge-shaped lobules of polygonal, nucleated, epithelial cells, supported by a fibrous stroma. The cells towards the centre undergo a waxy or hyaline degeneration, and in them are seen numerous rounded bodies, which have been supposed to resemble psorosperms. *Treatment* consists in cutting or pulling them away, or in cutting them across, and squeezing the contents out from the well-defined capsule.

Rodent Ulcer (basal-celled carcinoma) is a special variety of glandular cancer, commencing either in the sebaceous glands or in the basal layer of the rete Malpighii. It is usually met with in elderly patients, though occasionally observed in those under forty, and is seen with special frequency on the upper two-thirds of the face, the skin below the inner and outer canthi being the chief seats of election. It commences as a papule or flat-topped nodule in the skin, surrounded, perhaps, by an area of hyperæmia. The infiltration extends gradually in all directions, but the ulceration usually keeps

pace with the new growth. The ulcer has a smooth but somewhat depressed surface, is perhaps covered with granulations, and bounded by a slightly raised, indurated, rolled-over edge (Fig. 143). In most cases one can detect evidences of the new formation beneath the skin beyond the edge. If kept aseptic, there is but little discharge, and imperfect attempts at cicatrization are often observed, the scar, however, readily breaking down; but when septic, the surface is covered with sloughs, and an abundant offensive discharge escapes. The condition is painless; neighbouring lymphatics are not enlarged, and the general health does not suffer, except in the later

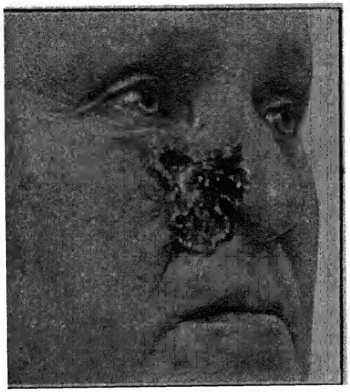


Fig. 143.—Rodent Ulcer of Many Years' Standing.

stages. The progress of the case is slow, but continuous, and although it spreads for a time superficially rather than deeply, sooner or later underlying structures become involved, and then nothing hinders the destructive process, even the bones of the skull being eroded, and the dura mater exposed.

Microscopically, the growth consists of interlacing columns of epithelial cells, interspersed with fibro-cellular tissue (Fig. 144). The constituent cells are small, globular, and closely packed, never of the 'prickle-cell' type, and rarely show signs of keratinization; hence 'cell-nests' are uncommon, although they are sometimes observed. The cells of the peripheral layer, however, are often elongated and arranged side by side like a palisade. The deep processes spread laterally rather than deeply beneath the unaffected skin, the papillæ of which are atrophied; their outline is clearly defined, and frequently angular on section. There is but little infiltration of round cells around the epithelial columns.

Treatment.—There are only two efficient methods of dealing with rodent ulcer, viz., excision and radio-therapy; the use of caustics has been entirely superseded. Where possible, the method of choice consists in free *excision*, a margin of at least half an inch all round being allowed; the defect is then made good by neat suturing, skin-

grafting, or some plastic operation. Inasmuch as the most frequent site of the trouble is the face, the ultimate æsthetic effect must be most carefully considered.

Radio-therapy by means of X rays or radium is on the whole more satisfactory in the great majority of cases. Formerly observers used massive doses at long intervals, but it is beginning to be realized

FIG. 144.—RODENT ULCER.

that a continuous series of small doses produces better results. A complete healing of the part may follow, with disappearance of all the thickening, but recurrence is not uncommon, and then a repetition of the irradiation is often unsatisfactory. The influence of the rays upon the healthy cells of the part is of a depressant character, and hinders them from taking their due share in the reparative process which is essential.

CHAPTER XVIII.

AFFECTIONS OF MUSCLES, TENDONS, AND BURSÆ.

Injuries of Muscles and Tendons.

Contusion.—Muscles are bruised as a result of blows or falls, leading to more or less extravasation, with possibly some rupture of the fibres. The part becomes tender and swollen, and any active contraction gives rise to pain; passive movement, however, is tolerated if the injured fibres are not thereby put on the stretch. Fomentations and rest may be needed for a few days; but regular massage, and perhaps elastic support, are subsequently necessary.

Sprains and Strains, due to violent efforts or falls, result in the tearing or stretching of some of the fibres. Considerable pain and stiffness follow, especially in rheumatic and gouty patients. Rest and firm pressure should be used at first, to minimize effusion or to ensure its absorption. The limb must be placed in such a position as to relax tension on the injured part, and often a pad or firm bandage over the tendon at a little higher level will steady it and enable it to be used without pain. Elastic pressure, massage and the alternate application of hot and cold water will do much to ensure complete recovery, which is most important, especially in subjects liable to rheumatism or tubercle.

Tennis Elbow falls into this category. It is usually due to a strain of the pronator radii teres, induced by a sudden twist of the forearm in the effort to put ' top spin ' on the ball, and occurs most commonly in the earlier part of the tennis season, before the muscles have become habituated to the unusual exercise. Aching pain is experienced in the front of the forearm, and efforts at active pronation are agonizing. Complete rest from the game for a time is essential, and the pressure of a firm bandage or strapping over the painful part desirable; massage and remedial exercises are subsequently required.

Tennis Leg, although an unfamiliar condition in this country, is well known in America The term is used for defining a group of injuries characterized by slight or more serious damage to the muscles, tendons, and aponeuroses forming the triceps cruris. Under it are also included injuries caused by a violent strain of the plantaris tendon. Early fixation in full plantar-flexion is the treatment to be adopted, followed by the use of a high-heeled boot when the patient begins to walk about.

Rupture of the Sheath of a muscle is an accident occasionally met with, especially in the adductors and rectus abdominis. The belly of the muscle, when contracted, protrudes through the opening as a hernia, constituting a soft semi-fluctuating swelling. In treating this condition the limb must be kept at rest in such a position as to relax the muscular fibres and allow the rent in the fascial sheath to heal. In old-standing cases it is justifiable to cut down upon and expose the opening in the muscular sheath, the edges of which are

sutured together, or if this cannot be effected a graft of fascia lata or a sterilized sheet of silver foil may be stitched over the defect.

Displacement of Tendons rarely occurs, except in parts where these structures pass through osseo-fibrous canals, and particularly in those where the line of action is thereby changed. During some violent effort the patient feels a sudden localized pain, followed by a certain amount of limitation of mobility. This accident is popularly known as a 'rick.' In superficial parts the displaced tendon can sometimes be distinctly felt in an abnormal position, and this becomes more evident on attempting to move it. Thus the long tendon of the biceps may be dislocated from the bicipital groove; and various tendons about the wrist or ankle, especially that of the peroneus longus, may similarly suffer. If left alone, the parts settle down more or less comfortably, but some permanent weakness may persist; recurrence is very likely to ensue if movement is permitted before the newly-formed connections have had time to consolidate.

Treatment consists in fully relaxing the muscles and replacing the tendon, if possible, by manipulation. The parts are then immobilized for six or eight weeks by a plaster of Paris splint or strapping. If the displacement recurs, it is sometimes advisable to expose the tendon, and stitch it back into position, using early passive movement to prevent the formation of troublesome adhesions. This is required most frequently in the case of the peroneus longus tendon, which slips forwards from its groove behind the external malleolus. The external annular ligament is thereby ruptured, and the operation consists either in suturing the divided segments, or in more aggravated cases it may be necessary to turn down a flap of periosteum from the malleolus, and by stitching its apex to the outer side of the os calcis secure the tendon in place.

Rupture of Muscles and Tendons is by no means uncommon, resulting from violence of an unexpected nature. Most frequently the tendon gives way at its union with the muscular belly; less often the belly itself yields, whilst occasionally the tendon may snap, or the point of bone to which it is attached may be torn off.

Signs.—The patient at the moment of the accident experiences a sharp and severe pain, as if he had been struck with a whip; he may also feel or hear a snap. Loss of function follows, together with a certain amount of pain, swelling, and bruising, which are more evident if the muscular fibres have been torn across than if the tendon alone has been lacerated. On attempting to contract the affected muscle, the belly rises up as a soft, rounded, semi-fluctuating tumour, drawn towards the uninjured attachment, if the union between the tendon and belly has given way; whilst if the lesion has been through the muscular substance, the divided halves of the belly become similarly prominent, and a distinct gap or sulcus can be felt between them.

Repair is established by the formation of granulation, and finally of cicatricial tissue. Where a muscle is involved and the ends are much separated, a long and weak bond of union forms; but when they are closely apposed, the cicatrix is short, and may be replaced

divided or torn, the connecting medium is at first attached to the sheath, and if this adhesion persists, it may lead to pain and weakness. It is an interesting fact to note how rapidly this tissue becomes strong; a rabbit's tendon ten days after division requires a weight of 56 lbs. to break it (Paget).

Treatment.—It is essential to relax the parts fully so as to limit the separation of the divided ends, and to maintain them in this position for two or three weeks. Any resulting stiffness is combated by passive movements and massage, whilst, if need be, adhesions are broken down under an anæsthetic. Tendons accidentally divided in open wounds should be sutured together by silk or catgut, careful antiseptic precautions being adopted to prevent suppuration along the tendon sheaths. Where there has been actual loss of substance in a tendon, one may be split longitudinally in such a way as to leave a thin flap attached peripherally, so that the free end can be turned down and united to the other segment (Fig. 145); or similar flaps may be provided from each end (Fig. 146); or it is possible to remedy the defect by grafting a portion of tendon from another region or person, or from an animal, between the two ends. Care must be exercised to prevent opposing muscles from dragging on and stretching the new bond of union, as thereby considerable functional disability may result.

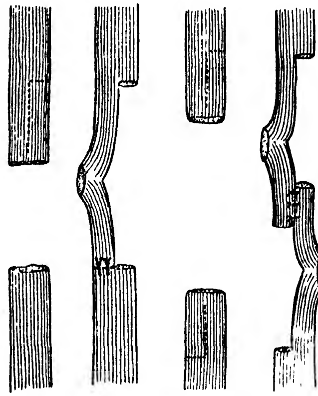


FIG. 145. FIG. 146.

METHOD OF UNION OF TENDON AFTER LOSS OF TISSUE.

In Fig. 145 the flap is taken from one end only; in Fig. 146 from both ends.

Muscular bellies which have been divided longitudinally or obliquely are easily united by sutures; but when the section is transverse, the stitches tend to cut out, unless the sheath can also be secured. In such a case it is advisable to encircle with a ligature a bundle of muscular fibres on either side of the incision, and then tie the two threads together. This must be done at several spots in the cross-section.

The *long tendon of the biceps* is not unfrequently torn from the muscular belly, which, on attempting to bend the arm, is drawn down towards the elbow, constituting a soft tumour, somewhat resembling a lipoma. No special treatment is needed beyond keeping the fore-arm flexed for a time. If the *tendo Achillis* is ruptured, union may be attained by keeping the knee bent and the heel raised, as by securing a strap to the back of a slipper below, and to a dog-collar or suitable strap passed round the knee above. A better

result, however, would follow an aseptic incision and suture. Similarly, if the *ligamentum patellæ* is torn across, suture through an open wound gives the best result. The *inner head of the gastrocnemius* is sometimes torn in wrenches or slips, as at lawn tennis, and the *plantaris* is similarly affected (see p. 457). The *adductor longus* may be lacerated in violent attempts to maintain a seat on horseback, and constitutes one form of rider's sprain; it is treated by rest and the application of a firm spica bandage, but in bad cases operation may be required.

The *long tendons of the fingers* are not unfrequently divided accidentally, and unless they are effectively sutured considerable impairment of function will result, the finger remaining in a position of flexion or hyper-extension, according to whether the extensors or flexors are involved. Operation to secure the divided ends should be undertaken at the earliest possible moment, but not until suitable aseptic conditions are present. Owing to the existence of a sheath the *flexor tendons* retract considerably, and a longitudinal incision in the middle line of the finger may be required to reach the proximal end. Its position can be indicated by the passage of a probe up the sheath, which is *incised only opposite the retracted end of the tendon.* A suture is introduced into the tendon and carried down the sheath, and thereby the retracted tendon is drawn again to the site where it was divided and secured to the distal end. By this manœuvre an extensive incision of the sheath is avoided, and adhesions are minimized. The finger must subsequently be kept on a splint, and active movements are not permitted for ten days.

The *extensor tendons* have no synovial sheath on the fingers, and hence there is but little difficulty in securing them by suture, except when the attachment to the terminal phalanx is torn through, a not uncommon accident. The aponeurosis retracts and the thickened divided end can be felt opposite the centre of the second phalanx; the terminal phalanx is bent and constitutes the condition known as a *mallet finger.* Fixation of the finger in a position of extension is useless in this condition, as approximation of the tendon to its point of attachment is not effected. Open operation is often unsatisfactory, since the tendon is torn completely away from the bone, and there is nothing to which to fix it. Good results are often obtained even at a comparatively late stage by putting up the finger with the metacarpo-phalangeal and first interphalangeal joints fully flexed, the second interphalangeal joint being extended —an uncomfortable position at first. The extensor aponeurosis is so attached that flexion of this type drags it downwards and relaxes its terminal segment so that satisfactory union is by this means much more likely to occur.

Contraction of tendons with a resulting deformity or disability will be produced by any condition which leads to destruction of muscle substance or partial loss of the tendon itself. It is likely to be associated with adhesions of the muscle to skin or fascia, or of the tendon to its sheath, and in military work may be complicated by

nerve lesions. Occasionally it develops apart from open wounds as in Volkmann's contracture and in certain nerve lesions. The possibility of the occurrence of this trouble should ever be kept in mind by the surgeon, so that preventive measures may be early instituted. When contraction has occurred, it is sometimes possible to overcome it by massage and ionization; but when a powerful muscle, such as the gastrocnemius, is involved, it is probably wiser to divide the tendo Achillis, and this should be effected not by subcutaneous cross-section, but by open or subcutaneous division according to the Z-method (p. 468), so that the exact degree of lengthening necessary may be secured. In the case of less powerful muscles, as when the fingers are affected, treatment by splints, as described at p. 462, may be effective; but when the tendons are adherent to their sheath this is not very satisfactory, unless the adhesions can be broken down and the tendon thereby freed.

Diseases of Muscles.

Inflammation of Muscles (Myositis) may arise from a variety of circumstances, but the chief results are alike, whatever the cause, viz., a more or less painful infiltration of the muscle, with increased discomfort on attempting movement. The part feels hard and rigid, and may be tender to the touch. If suppuration ensues, the ordinary signs of an abscess subsequently make themselves evident. A certain amount of contractile tissue is thereby destroyed, and the cicatricial changes induced will possibly lead to deformity.

Varieties.—1. **Simple Traumatic Myositis** results from contusion or laceration of the fibres, and is merely a plastic inflammation, with or without hæmorrhage, running on to resolution, with perhaps a little fibroid thickening of the part. It is liable in some cases to become chronic, the muscle substance becoming shortened and replaced by fibrous tissue (*M. fibrosa*), and this fibrosis may extend beyond the limits of the original lesion. The induration of the sterno-mastoid muscle met with in children is of this type, and may lead to torticollis.

A somewhat similar condition is known as Volkmann's **Ischæmic Contracture.** It is usually seen in children as a complication of fractures of the forearm or lower end of the humerus, which are treated by splints or firm bandages. At the end of two or three weeks the flexor muscles become hard and contracted, and the fingers flexed and clawed, the wrist being hyper-extended. The deformity of the fingers disappears on flexion of the wrist, demonstrating thereby that no adhesions of tendons to sheaths are present. It is recognized from a nerve lesion by the absence of sensory or trophic phenomena. It is probably due to a necrobiosis of the muscular tissue from deprivation of blood owing to the pressure of a splint or bandage, and this is followed by a spreading myositis fibrosa.

Treatment is somewhat tedious and painful. It is best accomplished by the persistent use of splints applied so as gradually to

stretch the contracted parts. Thus the hand is first put up with the wrist fully flexed and the fingers straight, though bent at the metacarpo-phalangeal articulation. By slow degrees the fingers are extended at this latter joint until the hand can be kept completely straight with a fully flexed wrist. The next stage consists in gradually extending the wrist with the hand straight, and it is remarkable how satisfactorily this treatment can restore the mobility of the hand and fingers, thereby avoiding the serious operative measures formerly adopted, such as lengthening of all the finger tendons or shortening of bones.

2. **Rheumatic Myositis,** or muscular rheumatism, is a condition often met with, especially in middle-aged men of rheumatic or gouty temperament who do not take enough exercise, and live well. Septic teeth are also a frequent cause. The condition mainly involves the fibrous tissues—*e.g.*, the fasciæ, aponeuroses, tendons, and sheaths of muscles, or the ligamentous tissues of joints; hence the name **fibrositis** is often applied to it. Some forms of neuritis result from a similar affection of nerve sheaths (p. 420). Any part of the body may be involved, but in particular may be noted *lumbago*, in which the fascia lumborum is affected, the patient walking with a stiff back slightly flexed; the pain often starts suddenly during some effort, and when present any unexpected movement elicits a sharp spasm. Rheumatic wry-neck is a similar condition, and may be induced by exposure to a draught. Pains in many joints—shoulders, knees, tendo Achillis, etc.—are of a similar nature, and sometimes are distinctly influenced by climatic conditions.

Treatment.—A good dose of calomel is in many cases desirable at the start, followed by suitable dietetic or medicinal remedies, and the teeth must be put into a good state of repair. Iodide of potassium is by some authorities looked on as always desirable. In the more active stages the part must be kept at rest, and dry or moist heat applied to relieve pain, whilst aspirin may be given for a similar purpose. Various methods of applying radiant or other forms of heat have been already alluded to (Chapter XI.). Vibro-massage is in many cases valuable. Hydrotherapy, when it can be utilized, is useful (p. 305). and the patient must be subsequently instructed to take more exercise and to live more simply.

3. **Acute Suppurative Myositis** is due to infection with pyogenic organisms, either from without, as after operation, or in penetrating injuries, etc.; or from within the body, as in pyæmia; or by extension from neighbouring suppurative foci, as from subperiosteal abscesses; it may also arise from a contusion or sprain by auto-infection. The local and general symptoms are severe, and pus is liable to spread widely within the sheath, or along fascial planes; great cicatricial deformity is likely to follow.

Treatment consists in providing efficient drainage to the part, the wound being dressed by one of the methods already indicated. This usually involves opening up the sheath freely, and the muscle may subsequently become adherent to the scar, and con-

siderable deformity, disability and pain may result henceforth on using the part. After gunshot wounds, where muscles are frequently torn and infected, these troubles are constantly met with, and the functional value of arms and legs is much diminished thereby. In the treatment of these cases care must be exercised to adopt that position of limb which will leave the least contracture, as thereby deformities may be prevented. When the scars have formed, ionization with sodium chloride often has a valuable influence in making them more supple, and massage assists in restoring utility to the part.

4. **Chronic Tuberculous Myositis,** with the formation of a chronic abscess, is not an uncommon secondary consequence of a similar affection of neighbouring bones or joints—*e.g.*, a psoas abscess.

5. **Syphilitic Disease** is usually met with in the tertiary period, and takes the form either of a diffuse sclerosis or of a localized gumma. Any muscle may be affected, but perhaps the tongue and sterno-mastoid are those most frequently involved. Care is needed in order to diagnose these conditions from tumours; but the presence of a syphilitic history and a positive Wassermann reaction, the slow growth, the hardness with subsequent central softening, and the rapid disappearance after the administration of iodide of potassium, should suffice to determine their nature.

Occasionally gummata appear in muscles in the shape of small, hard and shotty nodules, usually arranged more or less longitudinally, which are painless and apparently attached to the fascial sheath. They react readily to iodide of potassium.

6. **Parasitic Myositis,** arising from the presence either of the *Trichina spiralis* or of hydatids, need not be described here.

7. **Myositis Ossificans** is a rare disease, usually seen in young males, in which various muscles, especially those of the back, are transformed into bony plates or rods, so as to lead to extensive ankylosis. The process seems to be one of ossification of the connective tissue associated with atrophy of the muscular fibres, and is sometimes extremely painful. In a boy under observation the arms were immobilized by ossification of the latissimus dorsi muscles on either side, whilst the pectoralis major was also ossified on the right side. The erector spinæ was involved, the back being rigid, and the right trapezius was undergoing the same change. This disease is often associated with a congenital deficiency of the proximal phalanx of the great toes. No treatment has proved of any value.

Quite distinct in nature is the *Traumatic M. Ossificans,* of which two varieties are described: (i.) The new formation results from persistent and repeated irritation of muscles or tendons, and usually starts from the periosteal attachment. The 'rider's bone' developed in the tendon of the adductor longus is of this description. (ii.) Less commonly the affection follows a severe injury to a muscle associated with a fracture or dislocation, whereby the periosteum is torn and bone-cells (osteoblasts) are set free. A certain amount of

hæmorrhage follows, and in the reparative tissue developed in the muscle the bone-cells find a suitable nidus for development, and the new tissue formed undergoes ossification. In about three or four weeks the presence of bone can be recognised by palpation as a deep indurated mass, usually movable on the bone and across the fibres of the muscle involved; at a later date the new bone can be seen by radiography (R.S., Fig. 1). Painful limitation of movement may ensue, but if possible the condition is left alone, unless the disability is great, and then removal must be undertaken. The muscles in which this change has been most commonly observed are the quadriceps femoris and the brachialis anticus.

Tumours of Muscles are not very common. Primary growths consist of angioma, lipoma, fibroma, chondroma, myxoma, or sarcoma, and of these the majority start in the fibrous sheaths of the interfibrillar connective tissue. Secondary deposits of both carcinoma and sarcoma also occur. **Treatment** is conducted on ordinary surgical principles. If sarcomatous, the whole thickness of the muscles should, when possible. be excised for some distance from the growth, since the lymphatics run in the direction of the fibres, but the sheath forms a limit not early overstepped. Amputation of the limb may, however, be required.

Diseases of Sheaths of Tendons.

1. **Acute Simple Teno-Synovitis** often follows sprains and strains, and is most commonly seen in connection with the extensor muscles of the thumb. A puffy swelling in the course of the tendon is produced, painful on movement and perhaps tender to the touch, giving a characteristic fine crepitus whenever the parts are moved.

Treatment.—Immobilize the limb for a few days, and apply fomentations. As soon as the more acute symptoms have disappeared, massage is employed to hasten the absorption of the fluid; whilst active and passive movements are undertaken to prevent the formation of adhesions.

2. **Acute Suppurative Teno-Synovitis** may result from a punctured wound of the synovial sheath, or the inflammation may spread to it from neighbouring tissues. The thecal variety of whitlow (p. 267) is of this nature. Suppuration may extend both up and down the sheath, and unless promptly treated by incision, the tendon will slough, or may contract extensive adhesions to neighbouring parts; in either case considerable impairment of function is likely to follow. When the tendon survives, active and passive movements must be started very early if the formation of serious adhesions is to be prevented. The suppuration may affect neighbouring articulations, leading to their disorganization, especially in the case of the tendon sheaths around the wrist-joint.

3. **Chronic Simple Teno-Synovitis** is a common affection, characterized by a passive effusion into the tendon sheath of glairy synovia, somewhat resembling uncooked white of egg. An elastic fluctuating

swelling forms in the course of a tendon, usually associated with creaking. In the more limited varieties it constitutes one form of ganglion. There is no pain or tenderness, but the affected part feels weak. **Treatment** consists in counter-irritation and pressure, as by Scott's dressing; failing this, the part may be freely incised, the synovia removed, and, if need be, the cavity washed out. In the more localized forms it may suffice to puncture the cyst-like swelling and squeeze out the contents, pressure being subsequently applied.

4. **Chronic Tuberculous Teno-Synovitis** is of two types. In one the sheath is lined by œdematous granulation tissue of some thickness, containing tuberculous foci, giving rise to a soft elastic swelling along the course of a tendon, which increases slowly in size, and is but slightly painful or tender. Suppuration may follow, and subjacent bones or joints be involved.

The other form of tuberculous disease consists in a passive effusion into the synovial space, the lining membrane of which becomes thickened by the deposit thereon of fibrinous material. This is often detached, and by the movements of the part the loose fragments of fibrin are moulded into various shapes. In tendon sheaths they are often elongated, and constitute the so-called *melon-seed bodies;* but when they occur in joints, they remain somewhat flattened, whilst in bursæ they approximate more to the spherical. On examination, they are found to be structureless, though sometimes laminated. When numerous, they give rise to a curious and characteristic form of crepitus. That they are of a tuberculous nature can be demonstrated by inoculation experiments; the bacilli contained therein are not, however, in a very active state, and the prognosis of this type is more favourable than that of the former.

The **Treatment** of both these forms consists in the local application of the principles described at p. 194. The patient is put under the best climatic and general conditions that are possible, and the affected part is immobilized. The application of Scott's dressing may be desirable, and passive hyperæmia by means of an elastic bandage should be practised daily. Suppuration, if it occurs, is dealt with by tapping; but if the effusion in the latter variety becomes excessive, it may be wise to incise the sheath and wash out the melon-seed bodies together with the fluid; but under no circumstances should extensive operations be undertaken for the removal of the tuberculous tissue.

A **Ganglion** is the term given to a localized cyst-like swelling forming in connection with a tendon sheath or joint. It is most commonly met with at the back of the wrist, arising from the tendons of the radial extensors of the carpus, and those of the thumb or index-finger, but it sometimes occurs on the front of the wrist or in the foot (Fig. 147). It varies in size considerably, and contains a clear, transparent, gelatinous or colloid substance. A rounded, firm, elastic swelling is produced, usually somewhat movable, and neither painful nor tender at first, although some painful weakness of the part may be experienced as it increases in size. It may result

from a chronic localized teno-synovitis, or from a hernial protrusion of the synovial membrane through an opening in the sheath; certainly some few arise in connection with subjacent articulations, in the same way as a Baker's cyst. Little difficulty arises in the diagnosis, although, when situated deeply and closely attached to a bone, they have been mistaken for exostoses; their connection with a tendon sheath is indicated by the possibility of moving them at right angles to the direction of the tendon, but not up and down.

Treatment.—A ganglion may often be ruptured by manipulation and pressure with the thumbs. Failing this, a rapid cure is usually obtained by an aseptic puncture of the cavity, and the subsequent application of firm pressure. In some cases it may be advisable to lay the part open and remove the cyst wall as completely as possible; such treatment requires absolute asepsis, since, if infection occurs, most serious consequences may ensue.

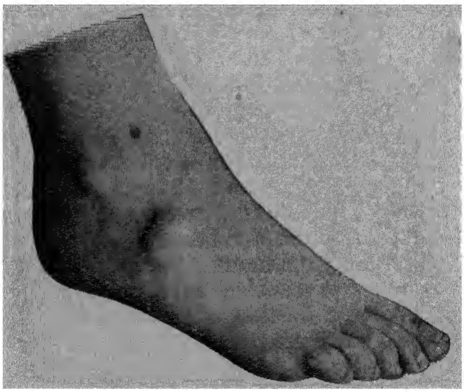


FIG. 147.—GANGLION OF EXTENSOR TENDON OF FOOT.

A **Compound Palmar Ganglion** consists in a tuberculous affection of the common synovial membrane surrounding the flexor tendons of the wrist, the cavity being distended in the early stage with a glairy fluid, usually containing many melon-seed bodies, and perhaps later on with pus. In the early stages all that is noted is a fulness about the front of the wrist and palm, the normal hollow being obliterated. Later on a more definite swelling is observed, and this is found to extend into the thenar eminence, due to the involvement of the tendon sheath of the flexor longus pollicis. The condition is painless at first, and there is but little interference with the mobility of the tendons; but in the later stages the tendons may become matted together, and the movements of the fingers hampered; or if the disease ends in suppuration, the pain and disability become more marked. In all stages fluctuation can usually be detected above and below the annular ligament, being transmitted beneath it.

Treatment is of the usual anti-tuberculous type. The patient is

sent to a sanatorium or placed in conditions approximating to it. The hand is kept at rest, but one full range of movements should be allowed daily so as to guard against unnecessary adhesions. Passive congestion by the use of a Martin's bandage is practised each day for an hour or two. If the effusion shows no signs of absorption after a sufficient interval, it may be removed by tapping and washing out, but there must be no handling or displacement of the tendons. Suppuration is dealt with by tapping, or if the skin becomes thin and undermined by free incision and packing with gauze soaked in iodoform and glycerine.

Operations on Tendons.

1. By **Tenotomy** is meant the division of a tendon through an open or subcutaneous wound with the object either of remedying some deformity, such as talipes or torticollis, or of assisting in the reduction of some displacement, as in setting a fracture. It is accomplished in two ways—viz., by subcutaneous or open incision. The **subcutaneous** method is employed where there is little likelihood of injuring important structures. The strictest attention to asepsis is essential, since the character of the wound, viz., a puncture, and the entire absence of drainage, are most favourable to the development of organisms, if entrance is once given to them. Moreover, the synovial tendon sheath is often, though undesignedly, wounded, and infection spreads rapidly along such a structure, and gives rise to serious consequences. The operation consists in inserting a sharp-pointed tenotome through the skin down to the tendon. This is then withdrawn, and a blunt-pointed knife passed along the track thus made, either superficial to or beneath the tendon. The cutting edge is turned towards it, and the tendon divided by a sawing or rocking movement, whilst the structure is put on the stretch. It is undesirable to operate through the synovial sheath, since even if the wound remains aseptic, the tendon often retracts more than is desirable, and in healing gains adhesions to the sheath, which considerably limit the subsequent freedom of movement of the part. Opinions vary as to whether it is better to pass the knife above or below the tendon; in the former method there is no likelihood of making an unduly large wound in the skin, and there is less risk of dividing the *lax* subjacent structures if the knife is turned towards them. On the other hand, if the knife is at once passed beneath the tendon, and any subjacent structures are by mistake included, their division is a matter of certainty. Where, however, there is any risk of dividing important structures, such as the external popliteal nerve in tenotomy of the biceps cruris, it is wiser to adopt the **open method.** The malposition is at once corrected, and the part immobilized at the time, or in the course of forty-eight hours, in plaster of Paris. Passive movements may usually commence at the end of twelve to fourteen days, and gradually be increased in vigour, until active movements are allowed.

Tenotomy of the Tendo Achillis.—The foot is placed on its outer side, and the tendon relaxed by pointing the toes downwards. The tenotome is introduced at the inner margin of the tendon, about 1 inch above its insertion (Fig. 113, F), either superficial to or be neath it, and it is readily divided when the foot is dorsiflexed. If the surgeon cuts towards the skin, he must not divide the last few fibres too rapidly, otherwise a considerable external wound may be inflicted by the suddenly liberated knife.

The *Tibialis Anticus* is usually divided about 1 inch above its insertion, as it crosses the scaphoid (Fig. 115, C), and is free from a synovial sheath. It is first relaxed so as to allow of the introduction from the outer side of the sharp-pointed tenotome beneath it; this is replaced by a blunt-ended instrument, and the section is accomplished when the foot is abducted.

The *Tibialis Posticus* is divided, together with the flexor longus digitorum, just above the inner malleolus, about a finger's breadth from the tip of that process in an infant, and about 1½ inches from it in an adult (Fig. 113, E). The knife is inserted between the tibia and the tendon, and if correctly placed, remains fixed without the support of the hand, being grasped between the tendon and the bone. The blunt-ended tenotome is then introduced with its edge towards the tendon, the latter structure being divided when the foot is dorsiflexed.

The *Peronei* tendons are divided just above the base of the outer malleolus, at a spot where the synovial sheath is usually absent (Fig. 114, D). The tenotome is inserted close to the fibula, between the tendons and the bone.

The *Biceps Cruris* tendon is best divided by an open operation, so as to avoid the external popliteal nerve, which has often been wounded in the subcutaneous method. An incision is made in the direction of the tendon just above its insertion into the fibula. It is then lifted upon an aneurism needle and divided; muscular fibres will probably be found quite close to its lower end.

The *Semi-membranosus* and the *Semi-tendinosus* tendons are dealt with just above the knee-joint, and the subcutaneous operation may be conveniently adopted when they are prominent and tense.

For division of the *Sterno-mastoid*, see p. 479.

2. **Lengthening a Tendon** is sometimes required, in order to overcome the deformity which results from loss of substance or contraction, where simple tenotomy does not seem desirable. The most efficient method is the so-called **Z**-operation (Fig. 148). The tendon is split longitudinally (*bc*) into two halves, which are separated one from the other by cross cuts made on opposite sides, one at each end (*ab* and *cd*). The two flaps are then drawn apart for a distance corresponding to the increase in length required, and sutured together; the resulting bond of union will be as represented in Fig. 149. This operation is usually performed through an open wound, but for the tendo Achillis it is quite easy to undertake it as a subcutaneous procedure. The tendon is half-divided on opposite sides

through two punctures $1\frac{1}{2}$ inches apart, and then by forcible dorsiflexion 'the two halves of the tendon are made to slide on one another until the required lengthening is obtained' (Robert Jones).

3. **Shortening a Tendon** is undertaken in some forms of paralytic talipes. The **Z**-method may also be employed here, the two halves, after they have been separated, being shortened to the required amount, and then stitched together (Fig. 150). This operation gives a more solid bond of union than when a transverse or an oblique section is removed; in such the sutures are more likely to cut out.

4. **Tenoplasty** is the term applied to any plastic operation on tendons with a view (1) to transfer the action of a healthy and strong muscle to the tendons of a weakened or paralyzed group, so as to limit deformity or disability; or (2) to displace the line of action of a muscle so as to counteract or obviate deformity; or (3) to utilize a paralyzed tendon as an accessory ligament. Clearly, this operation finds its greatest use in paralytic affections. It is essential to study carefully the peculiar features of each case,

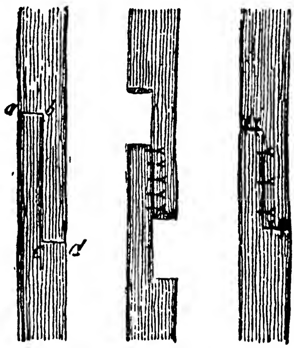


FIG. 148. FIG. 149. FIG. 150.

Z-OPERATION FOR LENGTHENING OR SHORTENING OF TENDONS.

In Fig. 148 the method of dividing the tendon is shown. In Fig. 149 the flaps are slipped downwards, one on the other, so as to lengthen the tendon. In Fig. 150 equal portions have been cut away from each half and the remainders sutured, so as to shorten it.

especially as to the electrical reaction and power of all the muscles involved, and the relative importance of each possible movement. Thus, in the foot, plantar-flexion is of more value than dorsiflexion, and the latter is more useful than either adduction or abduction, whilst of the two last-mentioned movements adduction is more important than abduction. Hence, although it would be mechanically correct to transplant a healthy abductor, such as the peroneus longus, into a paralyzed plantar flexor, such as the tendo Achillis, so as to improve plantar-flexion at the expense of abduction, it would be unwise to reverse the proceeding. It is desirable that, whenever possible, the reinforcing tendon should be derived from a synergic and not from an opposing group.

Various methods of tenoplasty are available: (1) *Tendon Implantation* consists in suturing the whole or part of the proximal end of the tendon of a healthy muscle to the distal end of the divided tendon of a paralyzed muscle, and for choice the latter should be divided as near its insertion as possible. The actual method of union of the tendons varies with circumstances, but the best results have been

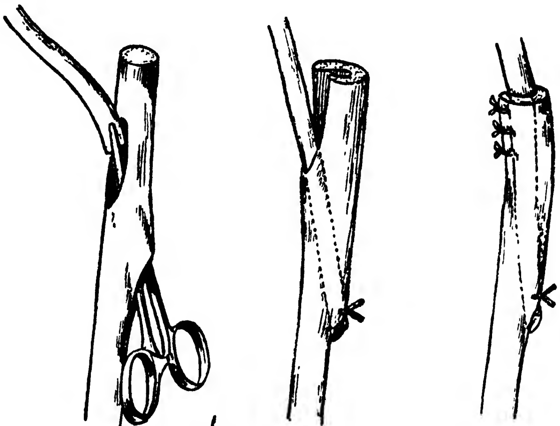


Fig. 151.—Tendon Im ~~Trans~~plantation. (Robert Jones.)

A hole is tunnelled obliquely through the healthy tendon, and the paralyzed tendon is drawn through this and fixed by sutures. At the free end the receiving tendon is split longitudinally and wrapped round the paralyzed tendon, so as to improve the fixation.

obtained by tunnelling the healthy tendon and drawing the divided end of the paralyzed tendon through it, and uniting them thus by sutures (Fig. 151). Direct end-to-end suture of two tendons is less satisfactory. Occasionally merely a slip from the stronger tendon is employed, which is attached to the weaker one so as to fortify the latter without destroying the power of either. (2) By *Tendon Transplantation* is meant the total detachment of a tendon from its point of insertion with or without the periosteum or bone to which it is attached, and its transference and fixation to the point of insertion of the tendon of a paralyzed muscle, or to some spot where it can act more advantageously. It is fixed either by sutures to the periosteum, or by drilling a hole through the bone and threading the tendon through it. (3) A somewhat similar procedure, which may be termed *Tendon Fixation*, is sometimes employed in order to steady flail-like paralyzed parts. Thus in hopeless foot-drop of paralytic origin it may be desirable to divide the extensor or peronei tendons and attach their distal segments by suitable methods to the tibia to act as accessory ligaments.

The greatest care must be taken with the technique of these operations, so as to ensure complete asepsis and perfect hæmostasis.

Tendon sheaths must be closed by the finest catgut or silk sutures. Deformities should be corrected before the tendons are united, so as to ensure accurate length of the new structure. The after-treatment is in the first place directed to the avoidance of undue tension on the bond of union for fear that it may stretch. The parts should be kept in an over-corrected position for six weeks by splints or plaster of Paris. Subsequently a supporting instrument must be worn for six months, and the affected muscles are treated by massage, electricity, and educative exercises.

Diseases of Bursæ.

Bursæ exist as normal structures in many parts of the body exposed to pressure, their object being to diminish friction and permit of a gliding movement. Similar cavities, known as abnormal or **Adventitious Bursæ,** are developed in regions where exceptional pressure is brought to bear on some prominent structure; they consist of a fibrous wall lined by a serous membrane, contain a small quantity of serum, and are formed either by dilatation of lymphatic spaces, or as a result of a localized effusion into the tissues. Examples of this are met with in men following special occupations—*e.g.*, over the vertebra prominens of Covent Garden porters, and then known as a 'hummy'; Billingsgate fish-carriers occasionally have bursæ under the centre of the scalp; and deal-runners often present one on the upper part of the shoulder. They occur over bony prominences arising from malformation or displacement—*e.g.*, over the cuboid in talipes equino-varus, and over exostoses; whilst the false joint or pseudarthrosis which occurs in unreduced dislocations or ununited fractures is of a similar nature.

Wounds of bursæ may be caused by penetrating injuries, or sometimes by the skin over them splitting, as, *e.g.*, in a fall on the point of the olecranon. The escape of bursal fluid which results often prevents healing, and then it will be necessary either to excise the bursa, or to open it freely, so that it can be packed and allowed to heal from the bottom.

Subcutaneous injuries are followed by hæmorrhage, constituting a hæmatoma, which may suppurate or become absorbed, in the latter case adhesions will often occur, and even polypoid fringes from the organization of the blood-clot. Treatment consists in keeping the part at rest, unless suppuration is threatening, and then an incision must be made. It is always well to make certain that no fracture is present beneath a hæmatoma of the olecranon or patellar bursæ.

The following are the morbid conditions which arise in adventitious as well as normal bursæ:

1. **Acute Simple Bursitis** results from moderate injury or prolonged irritation, especially in gouty or rheumatic individuals. The part becomes swollen, painful, and tender, and if superficial the skin over it may be hyperæmic. Effusion into the cavity quickly occurs, and is sometimes mixed with blood. Lymph is deposited

on the serous surface, and in many cases results in the formation of adhesions, and possibly obliteration of the cavity. **Treatment** consists in keeping the part at rest, and applying fomentations. If the effusion persists, aspiration, or removal with trocar and cannula under strict asepsis, may be employed, or even the whole cavity excised.

2. **Acute Suppurative Bursitis** arises from infection occurring either from without or within; it not uncommonly follows a subcutaneous injury of a chronically inflamed bursa, leading to its distension with blood. The pus, formed at first within the bursa, may travel directly to the surface, or, bursting through the capsule is diffused through the tissues. Where this occurs, the characteristic features suggesting a bursal origin of the abscess may be masked. Thus, in suppuration of the bursa patellæ, the pus often finds its way to the lateral aspects of the limb, allowing the patella to be distinctly felt through the skin; the case might then be mistaken for suppuration within the knee-joint, but is easily distinguished by the absence of the more acute arthritic symptoms. Implication of subjacent bones and joints sometimes occurs; thus, the patella or olecranon may become carious, or necrose. **Treatment** resolves itself into an early free incision, and drainage.

3. **Chronic Bursitis with Effusion** is, perhaps, the most common pathological condition met with in bursæ. The cavity becomes distended with a serous effusion of varying amount, giving rise to a fluctuating swelling. The walls differ in thickness according to circumstances; if the condition is one of long standing with frequent recurrences, the bursal wall is usually reticulated and dense, and adhesions, papilliform processes, or fibrous cords are often produced. Subacute exacerbations are frequent. **Treatment** consists in rest and counter-irritation, as by blistering or iodine paint, and if this fails, the bursa should be dissected out. When the bursa communicates with a joint, such as that under the semi-membranosus tendon, the neck must be isolated, and its communication with the joint shut off by ligature.

4. **Chronic Tuberculous Bursitis** is either characterized by effusion and the presence of loose fibrinous bodies (melon-seeds), or the lining membrane is transformed into granulation tissue of a tuberculous type, perhaps leading to the formation of a chronic abscess. Either condition may be secondary to a tuberculous arthritis, or may give rise to it, when the bursa communicates with a joint. If total removal is impracticable, **Treatment** is similar to that for chronic tuberculous teno-synovitis (p. 465).

5. **Syphilitic Changes** may also occur in bursæ, in the shape either of a symmetrical bursitis with effusion in the early stages, or later on as a gummatous perisynovial development. In this variety, often termed *chronic fibroid bursitis*, the walls of the bursa are much thickened, constituting a hard fibroid tumour, in the centre of which is a small cavity. If the gummatous material breaks down, deep openings may develop into the swelling (Fig. 35). Anti-

syphilitic treatment may assist in healing the sores, but total excision is necessary in order to cure the case.

6. Occasionally **Gouty Deposits** are observed in the walls of bursæ, constituting tophi, the irritation of which may predispose to abscess formation, pus mixed with urate of soda crystals being discharged. The olecranon bursa is that most frequently affected in this way.

Special Bursæ.

The *bursa patellæ* (Fig. 152), which lies over the lower half of the bone and not over its centre, is very liable, from its exposed situation, to injury or any of the above-mentioned varieties of bursitis. In its simplest form it constitutes the condition known as 'housemaid's knee,' and is due to kneeling. Caries of the patella may follow acute suppuration, and the more chronic varieties may lead to osteoplastic periostitis. The knee-joint itself usually escapes.

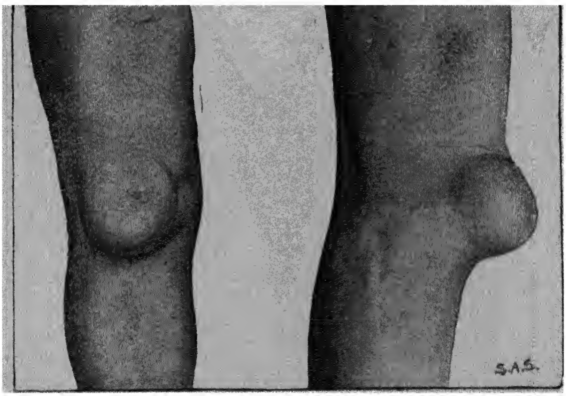


FIG. 152.—ENLARGED BURSA PATELLÆ.

The bursa beneath the ligamentum patellæ, between it and the head of the tibia, when distended with fluid, gives rise to a fluctuating swelling felt on either side of the tendon, more especially when the limb is extended; when the leg is flexed, the swelling diminishes. Chronic enlargement of this bursa may push the ligamenta alaria backward into the joint, so that they are nipped between the bones whenever the patient attempts to stand with the leg extended; the pain thereby induced is somewhat similar to that caused by a displaced semilunar cartilage, or by a loose foreign body in the joint. The presence of the enlarged bursa, together with the inability to stand with a straight leg, should suffice to make the diagnosis clear.

The *bursæ in the popliteal space* are often enlarged, especially that between the inner head of the gastrocnemius and the semi-

membranosus (Fig. 153), leading to a rounded fluctuating swelling, sharply limited on its outer aspect, and more fixed and less defined towards the inner. The sensation imparted to the fingers varies according to the position of the limb, the swelling being *tense in extension and flaccid in flexion*, as occurs in most of these periarticular bursæ. Owing to the proximity of the popliteal vessels pulsation is occasionally detected, but is not expansile in character. Enlargement of this bursa is often secondary to an articular lesion, especially tuberculous disease or osteoarthritis, and before undertaking treatment the condition of the joint should be ascertained. If the joint

FIG 153.—ENLARGED SEMI-MEMBRANOSUS BURSÆ IN BOTH LEGS OF A BOY

is healthy, the bursa may be removed by dissection, the pedicle being closed by ligature or suture.

The *bursa beneath the insertion of the semi-tendinosus and gracilis* is sometimes inflamed, and is very liable to cause osteoplastic periostitis of the subjacent inner surface of the tibia.

The *bursa beneath the tendo Achillis*, if enlarged, presents a fluctuating swelling on either side of that structure, somewhat simulating disease of the ankle-joint, but necessarily limited to the posterior aspect of the joint. Primary tuberculous disease is sometimes present.

Distension of the *bursa beneath the psoas tendon* gives rise to a fluid swelling which usually projects anteriorly, presenting either on the outer or inner side of Scarpa's triangle. If painful, it

necessitates flexion of the thigh, and thus leads to symptoms resembling those of hip-joint disease or of a psoas abscess. It must not be forgotten that this bursa often communicates with the joint.

The *gluteal* bursa, situated between the insertion of the gluteus maximus and the great trochanter, is not uncommonly the seat of tuberculous disease. It presents as a rounded swelling, obliterating the hollow behind the trochanter, and in its more acute manifestations may be accompanied by abduction and eversion of the limb, in order to relax as far as possible the gluteus. It may thereby somewhat resemble the earlier stages of hip disease, but is recognised by the absence of flexion, and by the fact that passive movements, including even the so-called test-movement for hip disease, can be undertaken with but little or no pain. Should suppuration occur, the pus may burrow widely beneath the gluteus. Treatment consists of complete excision, if possible, or incision with scraping and disinfecting the interior, and allowing it to heal from the bottom. Necessarily part of the insertion of the gluteus maximus will require division, and must be subsequently sutured.

The *bursa over the tuber ischii*, if inflamed, gives rise to the condition known as 'weaver's bottom'; it causes great discomfort in sitting, and is often solid and symmetrical. If troublesome, it should be removed.

Enlargement of the *bursa over the olecranon* constitutes the condition known as 'miner's elbow'; suppuration within it is not uncommon, leading to necrosis of the underlying bone; the elbow-joint is but rarely affected.

The large multilocular *subdeltoid bursa* is occasionally enlarged, and may be the site of a simple chronic effusion or of a tuberculous hydrops with melon-seed bodies. It leads to prominence of the deltoid, and expansion of the shoulder, which is liable to be mistaken for an effusion into the shoulder-joint, but is recognised without much difficulty, as the swelling is usually greater, and there is no axillary intumescence. Treatment consists in tapping and irrigation, or injection of iodine, or, failing that, drainage. As a final resource the deltoid can be partly detached and turned down, and the bursa dissected away.

CHAPTER XIX.

DEFORMITIES—ORTHOPÆDIC SURGERY.

ORTHOPÆDIC Surgery has for its aim the maintenance of the normal mechanical functions of the trunk and limbs, as well as the correction of such departures from the normal as constitute deformities.

Deformities may arise from many diverse **causes**, and it is essential to study them carefully from this point of view if correct treatment is to be secured. They may be *congenital* in origin, and thus may be inherited or the result of some lesion or defect in the health of the expectant mother; *traumatism* is the cause of not a few, either directly or as the result of inflammatory phenomena caused thereby. *Irregular growth* of various parts of the body from malposition or injudicious function is also an important ætiological element; especially is this the case in certain bony deformities, since the development of osseous tissue is so largely dependent on the strain to which the bone is exposed, and if this strain falls along abnormal lines, then abnormal growth will be Nature's response, and deformity will result. Muscles and ligaments must, of course, accommodate themselves to the bony skeleton. Quite a number of deformities are due to *static* causes of this character. Finally, the *nervous* system plays a certain part in many cases and in many different ways.

From the anatomical standpoint, deformities may be classed as due to the following causes:

1. Contractions of the skin, subcutaneous tissues and fasciæ, as in cases of burn, cellulitis, etc. Scar tissue does not grow as quickly as other tissues, and therefore deformity may sometimes become exaggerated as a child grows.

2. Unbalanced action of opposing groups of **muscles** from whatever causes this is due—*e.g.*:

(*a*) Simple want of tone from disuse, paralysis, etc., resulting in elongation of muscles or tendons.

(*b*) Persistent spasm, either clonic or tonic.

(*c*) Intrinsic contractions of the muscle substance, or adhesions of muscles or tendons to surrounding parts.

3. **Ligamentous** changes may lead to articular deformities.

(*a*) Simple relaxation from persistent malposition or chronic distension may lead to instability or even displacement of joints.

(*b*) Contraction of ligaments of static or inflammatory origin may result in more or less limitation of movement.

(*c*) Actual ossification of ligaments sometimes occurs, and causes ankylosis.

4. **Osseous** causes are most variable in type—*e.g.*,

(*a*) Irregularities of growth in the direction either of excess or defect may be congenital, static, or inflammatory in origin.

(*b*) Non-union or the vicious union of fractures is a fertile source of orthopædic trouble.

5. **Articular** causes are of manifold varieties, resulting from malposition, congenital or acquired, inflammatory troubles or traumatism.

6. **Nervous lesions** may cause paralysis or spasm, and many types of deformity result therefrom.

A careful study of the above ætiological summary will make it abundantly obvious to anyone that a large percentage of all deformities is preventable, and attention has already been drawn more than once in this work to the value of the old proverb that 'prevention is better than cure.' A very large proportion of the work undertaken at the orthopædic centres in connection with the late war could easily have been prevented with a little foresight and more care on the part of attending medical officers.

A few general principles which govern orthopædic treatment may be mentioned here, but it is obvious that space does not permit more than a brief note.

1. **Persistent malposition results in permanent structural changes.** Thus accommodative shortening of ligaments, muscles, etc., will take place on the flexor side of a bent knee or wrist, whilst the structures on the extensor side will be stretched and in time from want of use will become atrophied. Should the parts be subsequently replaced, the stretched extensors still remain weak and functionless, as the contraction of the muscles cannot 'take up the slack' in the tendons. The importance of this has been emphasized in connection with nerve lesions, whether traumatic or due to poliomyelitis. Joints conform to this rule, and ligamentous changes may even run on to ossification if there is much pressure or tension, the deformity thus becoming hopelessly fixed.

2. **Growth of bone** is governed by the amount and direction of the forces and strain to which it is exposed. Normal strain in a normal position means normal growth. Abnormal strain even in a good position may result in deformity, especially if the general condition is poor; but if time be allowed for repair and improvement of the general health, the bony tissue may recover and become consolidated in the abnormal position, and the resulting bony tissue may be more solid and stronger than ever. Thus in rickets the long bones often become bent, but strengthening buttresses develop in the concavity of the bent bones, and the final issue when repair has occurred is an abnormally solid bone. Similarly the kyphotic spine of 'hunch-backs' may become preternaturally powerful and solid.

On the other hand, want of use and loss of function are very quickly represented in bony tissue by atrophic changes.

If by operation or otherwise deformed parts can be placed in a normal position once again so that normal strains are brought to bear upon them, a return to a normal structure may be expected. This latter desideratum is, however, also governed by the age of the patient and the length of time that the deformity has lasted. In young people all growth tends towards the normal, but in older people the tissues do not respond so readily.

3. **Exercises** in which a displaced part can be brought either gradually or from the first into the normal position will develop the muscles, etc., which have become stretched, functionless, or atrophic, and as the normal position is more easily and effectively maintained, the structures which surround it return more exactly to the normal. The use of remedial exercises and re-educational methods is based on this fact. It must always be remembered, however, that it is useless to develop only one group of muscles without consideration of their antagonists. Muscles in the body are always balanced, and both groups must be capable of active functions if the movements of either are to be effective. (Cp. section on **Remedial Exercises**, etc., at p. 302).

4. The cure of deformities by position and exercises is, however, often a slow process in young people, and almost impossible in those who are older. Hence **Operative Treatment** is frequently required. Structures which are too short, *e.g.*, tendons, muscles, etc., may be lengthened; lengthened structures may be shortened; and displaced parts put in good position, and correct alinement of limbs thereby secured. One must again emphasize, however. that the replacement of the part in good position is only the commencement of the treatment; the development of the part in its good position so as to secure normal growth of the various structures concerned is just as important an element in the treatment, and herein lies the desirability of all students and practitioners studying in themselves and in their patients the functions and methods of exercising the various muscle groups.

The consideration of many orthopædic deformities has been or will be dealt with in other appropriate sections of this work, in this chapter it is proposed merely to discuss certain conditions which for convenience are grouped together.

Torticollis.

Torticollis, or wry-neck, is a deformity produced primarily by contraction of the sterno-mastoid muscle, although in old-standing cases the trapezius, splenii, scaleni, and other deep muscles of the neck, as well as the deep fascia, are affected. It is characterized by the affected side of the head being drawn down towards the shoulder, whilst the face is turned towards the sound side (Fig. 154).

Several different types are described, in particular the acute or rheumatic, the chronic, which is usually due to cicatricial changes in the muscle, and the spasmodic.

Fig. 154.—Chronic Torticollis.

The right sterno-mastoid is contracted, and the facial asymmetry is very noticeable.

1. The **Acute** or **Rheumatic** variety is usually the result of exposure to cold or to sitting in a draught; it comes on suddenly, and is extremely painful, and the muscle or muscles affected are tender to the touch. The possibility of mistaking it for other inflammatory affections, such as acute lymphadenitis or cellulitis, must not be overlooked; in them the neck is often fixed so as to protect the inflamed structures. **Treatment** must be general as well as local; aspirin may be given to relieve pain, or salicylates to counteract the rheumatic poison, whilst a dose of calomel or castor oil is always beneficial. Local fomentations should be applied in the early stages, and subsequently massage.

2. The **Chronic** form of torticollis is almost always due to cicatricial changes in the sterno-mastoid, which result in its intrinsic

shortening. (*a*) It is occasionally *congenital*, and then it is due to malformation or malposition *in utero*, whereby the muscle is imperfectly developed. (*b*) Most commonly it follows the *congenital induration* of the muscle (*q.v.*), due to laceration of its fibres during birth; it is therefore to be looked on as a myositis fibrosa. It is sometimes associated with winged scapula or other conditions due to injury of the muscular branches of the fifth and sixth cervical nerves inflicted at the same time as that to the sterno-mastoid. (*c*) At a later date contraction of the muscle may result from suppuration or gummatous formation within the sheath, but the deformity is then less marked.

Either the sternal or clavicular portion may be separately contracted, or the whole muscle may be affected, standing out as a hard tense band, the muscular substance being almost entirely replaced by fibrous tissue. The deep fascia is always secondarily contracted and shortened, and when the deformity has lasted long the posterior cervical muscles are similarly affected, whilst changes in the shape of the cervical vertebræ are also induced, the bodies becoming wedge-shaped, and thickest towards the convexity. A secondary compensatory curve is usually present in the dorsal spine, so as to maintain the horizontal position of the eyes. In children the affected side of the head and face also becomes atrophic. The measurement from the external canthus to the angle of the mouth is smaller, the eyebrow is less arched, the nose somewhat flattened, and the cheek less full than on the sound side. These phenomena are probably due to imperfect vascular supply, resulting from the limited mobility.

The **Diagnosis** of a chronic torticollis is readily made from the fact that the sterno-mastoid muscle is evidently contracted and stands out as a tense subcutaneous band. It must not be confounded with cicatricial contraction of the skin of the neck following burns, or with the deformity and rigidity of the neck which results from a rheumatic inflammation of the deeper ligaments and muscles of the cervical spine (rheumatic spondylitis), or from tuberculous disease of the cervical vertebræ.

Treatment.—Massage and manipulation may be first tried, or even some form of mechanical apparatus directed towards stretching the contracted muscle (*vide infra*), but in the majority of cases tenotomy or myotomy will give a more satisfactory result, and is less tedious and troublesome.

Two methods of dividing the sterno-mastoid have been employed: (1) The *subcutaneous* operation is a desirable proceeding, as it leaves no obvious scar, but requires great care in order to avoid damage to the important underlying structures. There is but little danger or difficulty in dealing with the sternal head, a tenotome being passed down to it beneath the skin, and the incision made from before backwards; the tension to which it is exposed suffices to draw it well forward out of harm's way. The clavicular portion, on the other hand, should generally be divided through an open incision. (2) The

occurs from the sixth. It is at first composed mainly of cartilage, but as age advances it becomes osseous. It may be short and have a free end in the neck, but more frequently passes down to unite with the first rib near the scalene tubercle, or to gain attachment to the sternum; occasionally, it consists of two portions, an upper and a lower, united together by a synchondrosis. No symptoms are produced until the mass by its growth encroaches on the subclavian artery and lower and inner cords of the brachial plexus. The vessel is pushed upwards and forwards, and becomes at times so prominent as to be mistaken for an aneurism; sometimes the pulse is impaired when the arm hangs down, and this may even determine gangrene of the finger-tips. Nervous symptoms are referable to the first dorsal and eighth cervical nerve-roots, and appear in the form of neuralgia along the ulnar border of the forearm and little finger, or of weakness mainly of the intrinsic muscles of the thumb. A cervical rib presents as a hard swelling above the clavicle, and can be readily recognized by radiography (R.S., Fig. 2). Nothing should be done unless pressure symptoms are present, when removal may be required. An incision is made parallel to the anterior border of the lower portion of the trapezius; the nerves and vessels are separated from the swelling and drawn aside, and the growth carefully excised by gouge, chisel, or cutting pliers.

Deformities of the Spine.

Scoliosis.—By scoliosis is meant a lateral curvature of the spine accompanied by rotation of the vertebræ. Conditions are met with in which the spine becomes deflected laterally as an occasional result of Pott's disease, or in fractures; these, however, are not generally considered to be genuine scoliosis.

Ætiology.—The following are the chief causes of scoliosis:

(1) It occurs very rarely as a congenital deformity, owing to malformation of the vertebræ.

(2) It may commence in young children as a result of *rickets*, owing partly to the softened condition of the bones, partly to their irregular growth. It is probably often induced by the children being always carried on the same arm, and the primary curve is usually in the dorsi-lumbar region.

(3) Any condition of asymmetry of the body may lead to what is known as *compensatory scoliosis*—*e.g.*, congenital shortness of one leg, unilateral dislocation of the hip, contraction of the knee- or hip-joint, genu valgum, falling-in of the chest wall as a result of empyema, unilateral paralysis of spinal muscles in infantile palsy, and even old-standing torticollis. If one leg is short (Fig. 155), the pelvis is tilted down on that side in order to bring the foot to the ground, producing a lumbar curve with the convexity towards that side, and then a compensatory dorsal curve in the opposite direction is subsequently added in order to maintain the general axis of the

body (A[1]). If, however, the short leg is also persistently adducted, as in old hip disease (Fig. 156, B), the spine will be curved in the opposite direction in order to maintain the parallelism of the limbs (B[1]).

(4) The most common type, however, is the *static* (or *postural*) *scoliosis of adolescents*, who are in a weak and asthenic condition, often as a result of rapid growth, combined possibly with improper or insufficient food, defective hygienic surroundings, or exposure to hard work, whereby undue muscular fatigue is induced. Young women of an anæmic type who suffer from amenorrhœa, and who as housemaids or factory hands have to undertake a good deal of lifting, are liable to this condition, and especially if their work involves a maintained position of lateral deflexion of the spine. It is largely due to a relaxed state of the ligaments and muscles, which have not developed *pari passu* with the weight and length of the

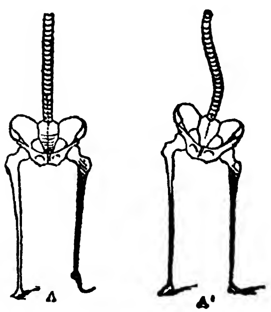


FIG. 155—SCOLIOSIS DUE TO SHORTENING OF THE LEFT LEG.

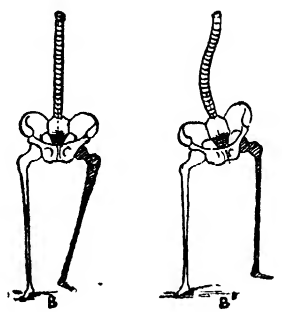


FIG. 156—SCOLIOSIS DUE TO ADDUCTION OF THE LEFT HIP.

skeleton, and is therefore not unfrequently associated with flat-foot and genu valgum. Prolonged standing in a position of ease or rest, in which the weight of the body is mainly carried on one leg, may determine its occurrence. School children develop this deformity readily as a result of the persistent adoption of faulty positions during reading or writing, owing to low desks and want of support to the feet. In addition to all these local phenomena, however, must be remembered the fact that the mental outlook of the majority of these patients is one of depression or pessimism, leading to a slouching gait with round shoulders and a prominent abdomen; the depressed state of her mind manifests itself in a relaxed habit of the body. A happy hopeful outlook on life helps to produce an upstanding frame of body with 'chest out and shoulders back.'

The **Phenomena** vary considerably according to the character and extent of the lesion. Sometimes the whole spine is involved in one

curve (*total* scoliosis); but more usually two curves are present, one primary, the other compensatory. It is by no means uncommon for this condition to be associated with kyphosis, but the absence of the latter, in what is sometimes termed the 'flat-backed' type, is no criterion of the slightness of the case. The most usual variety is that in which there is a double curve, with the dorsal convexity to the right and the lumbar to the left (Fig. 158). It will be desirable to describe this carefully, whilst for the opposite condition (Fig. 157) all that is necessary is to transpose the words 'right' and 'left,' or,

FIG 157 —SLIGHT SCOLIOSIS (TOTAL TO LEFT SIDE).

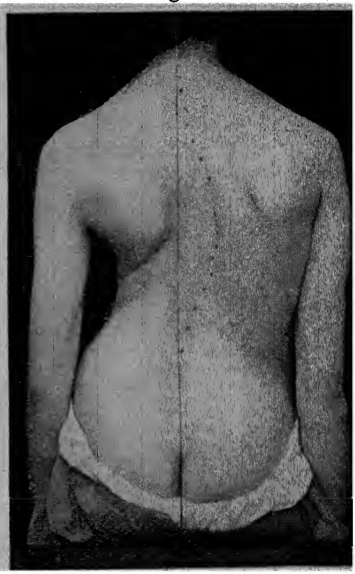


FIG. 158—MARKED RIGHT-SIDED SCOLIOSIS.

as Hoffa has put it, one variety is the 'mirror picture' of the other.

In addition to the lateral displacement, *the bodies of the vertebræ* are always *rotated* towards the convexity of the curves. This also occurs to some extent in normal flexion of the spine, and is a purely mechanical act, and due to the more firm support given to, and the interlocking of, the posterior parts of the vertebræ. As a result, the spinous processes are directed towards the concavity, and hence always indicate a smaller amount of distortion than really exists. Occasionally there may be some backward projection of the spines at the junction of the two curves.

The *thoracic walls* necessarily participate in the process, and the amount of thoracic deformity is perhaps the best measure of the

degree of rotation of the vertebræ. The ribs on the right side become to some extent separated from one another, and project posteriorly on account of this rotation (Fig. 159); the amount of curvature at the angle is consequently increased, whilst the front of the chest on this side of the body becomes flattened. On the left side the ribs are huddled together, and the curve at the angle diminished, the ribs being thereby opened out; consequently, the thorax is flattened posteriorly on that side, but projects in front; the left breast may thus be rendered prominent. In fact, the thorax becomes more or less rhomboidal in shape. The sternum also is somewhat displaced towards the concavity, and twisted so that the anterior surface looks towards the right. The capacity of the thorax is not as a rule affected at first, but in the later stages it

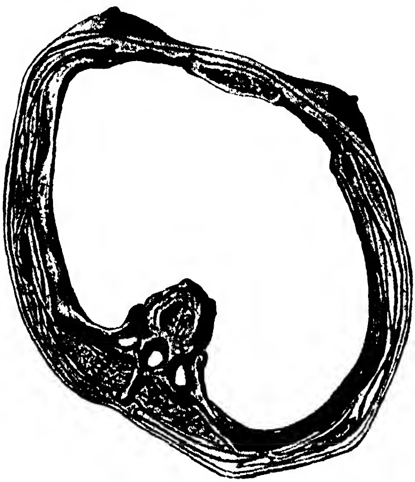


FIG. 159.—SECTION OF THORAX IN SCOLIOSIS WITH DORSAL CONVEXITY TOWARDS THE RIGHT SIDE

is considerably diminished, and the abdominal viscera may even be displaced. The *scapulæ* follow the thoracic wall, and hence the right shoulder is pushed upwards and outwards, and it is for this 'growing out of the shoulder' that the majority of cases come under observation. The effect on the *waist* varies with the situation and extent of the curves; if the dorsal and lumbar curves are nearly equal, then the true waist on the right side becomes more marked than usual, corresponding to the lumbar concavity, and in advanced cases a distinct sulcus may be present between the lower ribs and the crest of the ilium. On the left side the hip appears to project ('growing out'), owing to the deflection of the trunk towards the right side (Fig. 158), whilst the dorsal concavity higher up may simulate a false waist. The erector spinæ muscle stands

out unduly on the left owing to the rotation of the vertebræ, whilst the transverse processes on this side may be unusually evident.

In the early stages the characteristic deformity disappears on extension of the trunk, as by hanging from a trapeze, or on bending forwards; but as the condition progresses, the spine becomes more and more fixed, and but little alteration is produced by suspension of the patient. In the worst cases, especially when associated with kyphosis, the deformity becomes so marked as to simulate the 'hump' formed in Pott's disease, and the patient's stature becomes dwarfed and stunted.

Subjective symptoms, such as neuralgic pain and weakness, are also present, but usually they are not very prominent features.

Anatomical Changes only occur in the later stages of the case, and conform to the general rules of such deformities. At first it is merely the muscles and ligaments that become affected in the direction of shortening on the side of the concavity and lengthening and relaxation on that of the convexity; these are merely accommodative phenomena. Later on, the vertebræ themselves may become misshapen, and wedge-like on section, being thicker on the convex than on the concave side. The intervertebral discs are similarly changed, whilst the articular processes are unduly pressed together on the concave side and separated from one another on the convex. The transverse and spinous processes are also approximated to one another on the side of the concavity and often curved.

It is most essential that a correct **Diagnosis** be made as soon as possible, since so much depends upon early treatment. A thorough examination should be made with the patient standing and the clothes stripped to below the waist, so that the whole back can be seen. The general appearance is first noted, and then the spinous processes are marked out one after another with a spot of ink or with a flesh pencil. The shape of the thorax, the curvature of the ribs, and the position of the scapulæ, are also ascertained, and the length of the legs is measured. The patient is then made to hang from a bar, and to bend forwards, and the effects of these respective movements noted; by this means some idea can be obtained of the extent and nature of the deformity. There can be but little risk of mistaking it for Pott's disease, since the rigidity, deformity, and localized pain of the latter are so characteristic; in bad cases of scoliosis, however, where there is a projection of the spinous processes backwards, a mistake might easily arise if only a careless examination were made.

The **Prognosis** necessarily varies with the stage which the affection has reached. In early days, before the deformity has become set, and when it disappears on extension of the spine, it is almost certain to be entirely cured, if suitable precautions are taken. Later on it can be improved to some extent, but in bad cases all that can be expected is to prevent it from getting worse.

In the **Treatment** of scoliosis, the cause of the trouble must not be overlooked, since in many cases the deformity may be remedied, or at any rate prevented from increasing, by attending to this. Thus, inequality in the length of the limbs necessitates the wearing of a high-heeled boot, whilst contractions of the knee- or hip-joints should, if possible, be corrected. In that variety which occurs in young people from constitutional or local debility, the general health must be improved by suitable measures. Carefully-regulated rest and exercise must also be recommended, so as to improve the muscular tone of the back without unduly fatiguing the patient; for a similar reason massage and cold baths are beneficial. All errors of position must be corrected, and suitable desks, forms, and chairs utilized. In the slighter cases it often suffices to order the patient to rest in the supine position on an inclined board for an hour or two daily, the head being thus raised and the spine extended Remedial exercises constitute the most important element of treatment, which may be looked on as curative in early and moderate cases, and as palliative in the advanced stage. Some of these are arranged so as to extend and render mobile the spine, and generally to improve the tone of the spinal muscles; others are devised so as to undo the abnormal curves present. Space forbids us describing them here, and we must refer readers to special textbooks.

A spinal support is occasionally useful, but should not be worn continuously, except in bad cases, as it renders the muscles of the back weak from disuse. All that is needed in the early stages is the support of a firm, carefully-fitted corset; but should the deformity increase, stronger instruments may be employed in which springs are incorporated, whereby it is hoped that correction of the curvature may be brought about. In the worst cases, where the deformity is irremediable, much can be done by a skilful mechanism to hide the deformity and prevent its increase; Albee's operation (*q.v.*) may also be useful for this purpose.

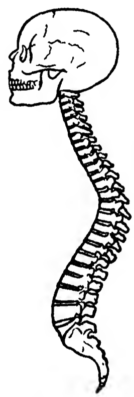


FIG. 160.—KYPHOSIS.

Kyphosis.—By this term is meant a condition of increased dorsal convexity of the back (Fig. 160), which is often associated with loss of the lumbar concavity, so that the whole spine is arched backwards. Occasionally, however, a marked lumbar lordosis is present as a compensatory condition.

The chief **varieties** of kyphosis are as follows:

1. Kyphosis from defective growth or habit. This may occur (*a*) in children under the age of four, resulting from rickets; (*b*) in adolescents up to the age of sixteen (round shoulders), from a continuous habit of stooping, as in reading or writing, especially in those suffering from myopia; (*c*) various forms of occupation which involve the carrying of heavy weights, or stooping over work,

lead to its appearance in adults, as in porters and cobblers (Fig. 161); (*d*) in old men it results from senile atrophy.

2. Kyphosis from general disease of the spine is a marked feature in spondylitis deformans, osteitis deformans, osteomalacia, hypertrophic osteo-arthropathy, and acromegaly. In the latter disease the condition is limited to the dorsal region.

3. Kyphosis also arises from localized injury or disease of the spine—*e.g.*, traumatic spondylitis, fractures, Pott's disease, gumma, or cancer.

Treatment is impossible in the majority of cases, but the round shoulders of young people come so commonly under observation that a little more notice of the condition is needed.

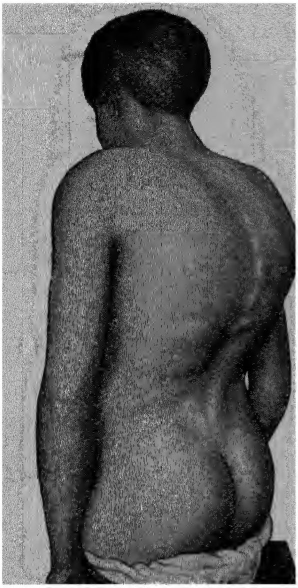


FIG. 161.—ACQUIRED OCCUPATION KYPHOSIS IN A YOUNG MAN FROM EXCESSIVE WEIGHT-CARRYING.

Round Shoulders occur most frequently in girls who have grown rapidly, and perhaps developed precociously. The condition is often due to defective habits of sitting and standing, especially at school, and may be induced by faulty desks and chairs, but other conditions such as myopia or adenoids may be primarily responsible. The deformity can be voluntarily corrected in the earlier stages, but not so later on.

Treatment.—In the first place the cause must be ascertained, and if possible removed; chairs and desks must be arranged so as to ensure that the child sits in a good position, and does not stoop when writing, reading, or playing the piano. In particular, the back should be supported whilst reading, and the feet should not be allowed to dangle. The muscles of the back, especially the trapezii, the erectores spinæ, the rhomboidei, and the serrati, must be strengthened by massage, electricity, and exercises, the latter necessarily directed towards extension of the back. Undue fatigue must be avoided, and the girl should rest on her back two or three times a day for half an hour. At night she should lie on her back, without a bolster, and with a pillow beneath the curve. The general nutrition and health must also be attended to, and a course of suitable tonics prescribed. In bad cases where the deformity is marked and it is feared it may be progressive, a light support may be required; a Chance's splint*

* Many modifications of Chance's original splint have appeared, but the essential features of all are the presence of a metal pelvic band, from which rises a single or double bar of malleable iron fitted to the back, and capable of having its curve altered. Lateral supports spring from the central bars or bar, and straps to fix it in position are also provided.

will do as well as any, but of course the exercises must be persisted in.

Lordosis (Fig. 162) is almost invariably a secondary or compensatory condition, and consists in an increased anterior curvature of the spine in the lumbar region. It is usually produced by continued flexion of the hip, whether due to congenital displacement, unreduced dislocation, malunited fracture, or to hip disease, and is irremediable unless the malposition of the femur can be corrected.

It is seen as a temporary condition in pregnancy, and as a more persistent phenomenon in bad cases of uterine fibroids, owing to the increased weight of the uterus or its contents, necessitating backward displacement of the upper part of the spine in order to adjust correctly the centre of gravity of the body. The same may be noticed in persons with large, fat, and pendulous abdomens.

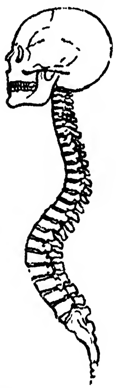


FIG. 162.—LORDOSIS.

It is occasionally present in progressive muscular atrophy where the lumbar and abdominal muscles are weakened, and usually in pseudo-hypertrophic paralysis from loss of power in the gastrocnemii and other muscles engaged in maintaining the erect posture.

Spondylo-listhesis is the term applied to a curious and somewhat uncommon deformity, in which the lumbar vertebræ slip forwards and downwards from the top of the sacrum. It arises from fracture of the articular processes of the lumbo-sacral joints, or from imperfect development of the laminæ or pedicles of the lowest lumbar vertebra, as a result of which the pressure of loads carried on the shoulders or the weight of a pregnant uterus brings about the displacement. In the latter instance the enforced lordosis aggravates this tendency. The effects produced are shortening of the stature, together with the formation of a marked hollow above the sacrum, whilst the lumbar vertebræ are unduly prominent anteriorly. The condition is accompanied by neuralgic pain and weakness. The only *treatment* is prolonged rest in the recumbent posture, and possibly the application of a leather jacket, moulded to the pelvis, and supplied with crutches, so as to carry part of the weight downwards from the axillæ to the pelvic support without utilizing the spine. Albee's operation suitably modified (p. 794) may be undertaken with advantage in cases where rest does not avail.

Deformities of the Upper Extremity.

In **Congenital Elevation of the Scapula** (Sprengel's Shoulder) the scapula may be normal in size or a little smaller than usual, but is situated above its proper position, and rotated so that its lower angle is approximated to the middle line. The muscles attached to its upper border are prominent; in a few instances a cartilaginous

or osseous band has replaced them, passing between the upper angle of the bone and the seventh cervical vertebra. The lower third of the trapezius is often defective, as also the serratus magnus. The disability, which is usually slight, depends on the condition of these muscles, but the affected arm is sometimes smaller than its fellow. A slight degree of scoliosis develops as a compensatory phenomenon. The only active *treatment* consists in dealing with the affected muscles by removing the cartilaginous or osseous band; otherwise massage and exercises are required.

A **Winged Scapula** is a condition characterized by projection backwards of the vertebral border and lower angle of that bone when the arm is thrust forwards (Fig. 163). It is due to paralysis of the serratus magnus and rhomboids, which normally keep the venter of

FIG. 163.—WINGED SCAPULA.

the scapula in contact with the chest wall. It may be due to injury or division of the nerve of Bell in the axilla, or to irritation and compression of the fifth and sixth cervical nerve-roots, which may be tender; weight-carrying on the shoulder may also be responsible for this lesion. **Treatment** consists in massage and faradism, whilst, if persistent, a suitable appliance may correct the deformity.

A curious **Tilting** of the **Scapula** occurs in children where the spinal accessory nerve has been divided during operations on the neck, as for tuberculous glands. When the arm is raised or pushed forwards, the normal relation of the scapula to the spine is not maintained, owing to paralysis of the trapezius, but the bone is tilted upwards and outwards, so that a considerable hollow develops immediately behind the clavicle. It is unsightly, but not especially detrimental

and with growth and active exercise any ill-effects usually disappear. As a rule treatment is unnecessary, but if need be an attempt must be made to find and unite the divided ends of the nerve.

Cubitus Valgus and Cubitus Varus.—Under normal conditions the axis of the forearm does not correspond with that of the arm, the former being in a position of slight abduction (about 15°), constituting what is known as the 'carrying angle' (Fig 164, A). This angle is often greater in women than in men, and when marked constitutes the condition of *cubitus valgus* (C). It is usually due to fracture of the lower end of the humerus, involving displacement downwards of the inner condyle and callus formation. The ulnar nerve is likely to become unduly exposed beneath the skin, and thus to suffer recurring injuries of a neuritic type. If the causative bony lesion cannot be repaired, the nerve should be set

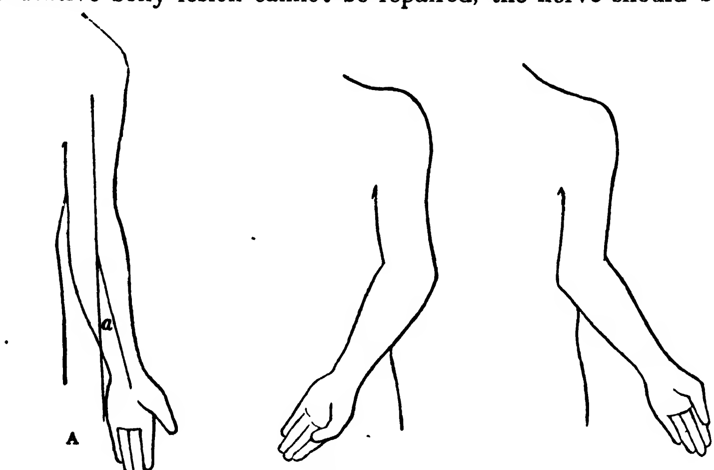


FIG. 164.—OUTLINES OF UPPER EXTREMITY TO SHOW A, NORMAL CARRYING ANGLE ($a=15°$); B, CUBITUS VARUS; C, CUBITUS VALGUS.

free and displaced in front of the condyle. *Cubitus varus* (B) is perhaps more common, and is due to similar lesions of the external condyle, or to displacement upward or defective growth of the inner. If function of the elbow is seriously impaired, a supra-condylar osteotomy may be required.

Various types of **Club-hand** occur, in which the hand is deflected to one or the other side, or is hyper-extended or flexed. Perhaps the most frequent cause is a *congenital absence of the radius,* under which circumstances the hand is radially abducted to a marked degree, the ulna is shortened and curved, and its lower epiphysis expanded, so as to articulate with the carpal bones. Where the bones are normal, the hand is usually flexed and adducted towards the ulnar side. In all of these deformities radiography should be employed, so as to ascertain the exact relation of the bones to each other.

Congenital Deformities of the Finger are much more common, and the account here given of such defects of the upper extremity applies with equal force to those which occur in the lower. The following varieties may be alluded to:

Polydactylism consists in the presence of supernumerary fingers and toes. There may be from one to seven additional digits, and the condition is usually symmetrical. The accessory digits are often stunted, and smaller in size than the normal, but may be of average dimensions. Usually they are separated from the true digits, but now and then may be blended with them. The correct number of metacarpal or metatarsal bones may be present, or they also may be multiplied. In one of our cases there were six digits and six metatarsal bones; but the last two digits were supported by

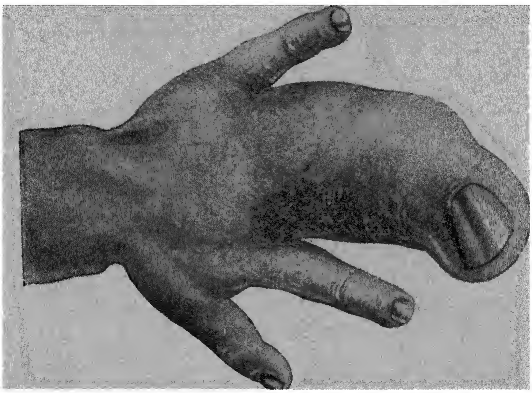


FIG. 165.—MACRODACTYLY AND SYNDACTYLY.

In this case a child, aged two and a half years, had the ring and middle fingers united laterally into a large mass which projected far beyond the others. The middle finger was normal in size, the ring finger was hypertrophic. A fruitless attempt was made to save the middle finger, but both had finally to be amputated.

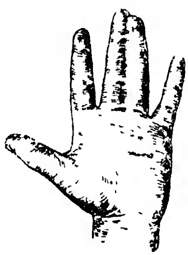
an accessory metatarsal apparently springing from the outer side of the fourth. The condition is frequently inherited. The **Treatment** consists in removing the supernumerary digits, if useless, obtrusive, or troublesome. Sometimes the patients are proud of their abnormality, and refuse to part with it.

Ectrodactylism, or the absence of one or more of the digits, is occasionally seen, as also partial arrests of development of fingers or toes, or intra-uterine amputation at a higher level.

Macrodactyly (Fig. 165) consists in a congenital overgrowth of one or more fingers or toes. The structures are perfectly normal in character, and merely gigantic in size for the age of the individual. Amputation or excision may be needed in these cases, as the deformed parts grow out of all proportion to the neighbouring tissues.

Thus, an infant with enormous overgrowth of the second toe of the right foot was successfully treated by excision of the digit. together with a V-shaped portion of the foot, which was by this means reduced to normal shape and size.

Syndactylism, or webbed fingers, is a condition in which two or more fingers are joined together laterally, either by a thin web consisting mainly of skin, or by a thick fleshy bond of union. In the foot no *treatment* is required, but in the hand the fingers must be separated. If there is merely a thin web, this may be divided by scissors; but to prevent its re-formation from above downwards, as healing proceeds, a flap of skin must be transplanted into the angle between the fingers, or an opening in the base of the web may be made and maintained, and the edges allowed to cicatrize before the web itself is divided. Where the union, however, is thick and fleshy (Fig. 166), a more extensive operation is needed. Two flaps



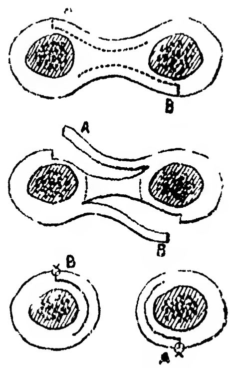


FIG. 166.—SYNDACTYLY. FIG. 167.—OPERATION FOR SYNDACTYLY.

of skin as long as the web, and half the width of a finger, are respectively raised from the dorsal aspect of one finger (Fig. 167, A) and from the palmar aspect of the other (B), in such a manner that, after the web has been divided, the denuded surfaces can be covered by wrapping the flaps round the lateral aspects of the fingers and suturing them in position. An additional flap of skin must also be fixed in the angle between the separated digits.

A similar condition is occasionally developed after burns or wounds involving the webs between the fingers. It is usually preventable if the fingers are kept well apart and early skin-grafting is undertaken. Otherwise the scar must be divided and the raw surface produced thereby grafted, or operative treatment more or less similar to that described above undertaken.

Congenital Contraction of the Fingers is not a very rare deformity, being frequently inherited; it is usually limited to the little finger, and may be associated with congenital hammer-toe. It is due to contraction of the *central* prolongation of the palmar fascia in the finger.

whereas Dupuytren's contraction involves the palmar fascia itself and its *lateral* prolongations into the fingers. Moreover, in the congenital variety the first phalanx is hyper-extended, and the second and third flexed, whereas in the acquired form the first and second phalanges are flexed and the third is hyper-extended. **Treatment.**—It often suffices to use massage and apply a splint, but in bad cases division of the fascial bands may be needed.

Acquired Deformities of the Hand.—After burns the hands may be contracted into a useless mass in which the fingers are drawn into the palm and united by cicatricial tissue to the palmar structures, so that all treatment is hopeless.

For deformities due to damage to the tendons of the fingers, see p. 460.

Spring-, Jerk-, or Snap-finger is a condition in which, when the patient attempts to open his hand, one finger or the thumb remains flexed, and on extending it with the other hand it flies open with a jerk or snap. Slight tenderness is usually felt near the metacarpophalangeal articulation, and the cause of the trouble is some obstruction to the free working of the long tendons under the transverse ligament at the root of the fingers, or between the sesamoid bones of the thumb. In a few cases a ganglion has been present here, but in most instances the condition is due to an increase in size of the sesamoid bone, which radiography has taught us occurs constantly in this situation. **Treatment** consists in an aseptic incision to remove the cause of the obstruction.

A **Mallet Finger** is one in which the terminal phalanx is maintained in a state of flexion owing to some damage to the extensor aponeurosis. Its **treatment** in the early stage has been already alluded to (p. 460); should the deformity be persistent, an incision is made on the posterior aspect of the finger, and the weak tendon isolated and stitched down in such a way as to give it a better attachment to the bone.

Contraction of the Palmar Fascia (Dupuytren's Contraction).—This condition is usually met with in middle-aged individuals of a gouty temperament, more often in men than women, and not unfrequently on both sides of the body. It may or may not be associated with direct irritation of the palm, as by leaning much on a round-headed cane, or from the constant use of some instrument, such as an awl, whilst heredity is an important causative factor. Pathologically, it is due to a chronic overgrowth and contraction of the fascia, inflammatory in nature, and cirrhotic or sclerosing in type. It commences as an indurated subcutaneous nodule in the palm of the hand, about the situation of the most marked transverse crease, and affects most commonly the ring and little fingers first, the other fingers and thumb being less often involved. The induration spreads slowly both up and down the fascial bands into the fingers, and may even extend downwards beyond the normal limits of this structure, so as to cause acute flexion of the second phalanx, as well as moderate flexion of the first. The whole finger is thus gradually drawn into the palm and fixed, so

that extension becomes impossible (Fig. 168). The third phalanx always remains extended, and, indeed, sometimes assumes a position of hyper-extension, owing to the injudicious application of a splint. The skin over the indurated masses is sooner or later incorporated with them, and may become dimpled or creased by the traction of the subcutaneous connecting bands.

The **Diagnosis** of Dupuytren's contraction is exceedingly easy, the only condition for which it is likely to be mistaken being the congenital contraction already noted, and the flexion of the finger due to contraction, division, or destruction of the long tendons. In the latter case there is, as a rule, no palmar induration, but there will be a history of injury or inflammation, and some scarring (see p. 461).

The only satisfactory **Treatment** is by operation; and the following methods are those which are most successful: (*a*) Adam's subcutaneous section of the fascia and its prolongations consists in dividing

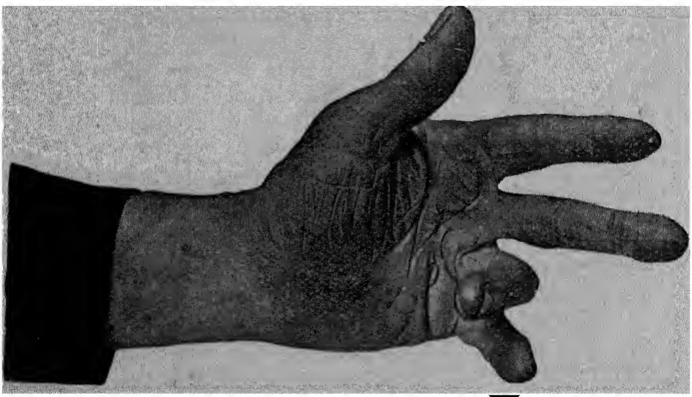


FIG. 168.—DUPUYTREN'S CONTRACTION.

the indurated bands by a tenotome in several places, where they can be felt tense. One puncture and division must be made in the centre of the palm; a second divides the same band as near the finger as possible, whilst the third and fourth deal with the lateral prolongations at the sides of the finger; if other bands still exist, they are treated similarly, the tenotome, if possible, in all cases being inserted between the skin and the fascia. The improvement thus produced must be maintained and increased by the subsequent use of suitable apparatus and passive movements, but the final results are not very satisfactory. (*b*) Kocher's method consists in the total extirpation of the thickened bands and their prolongations through longitudinal incisions. The fingers may be subsequently straightened with ease, but not unfrequently the first interphalangeal joint remains flexed in spite of mechanical appliances and massage. If therefore the flexion persists after effective removal of the fascial bands, it is wise to excise at the same time the

head of the first phalanx and shorten the extensor tendon through a transverse or semilunar dorsal incision. In this way it should be possible to straighten the fingers completely when the operation is finished. A splint must be applied whilst the wounds are healing, but early movements and massage are required if a good functional result is to be secured.

Deformities of the Lower Extremity.

Congenital Dislocation of the Hip is by no means rare, although its causation is still quite uncertain. It is frequently bilateral, though more commonly unilateral; it occurs much more often in girls than

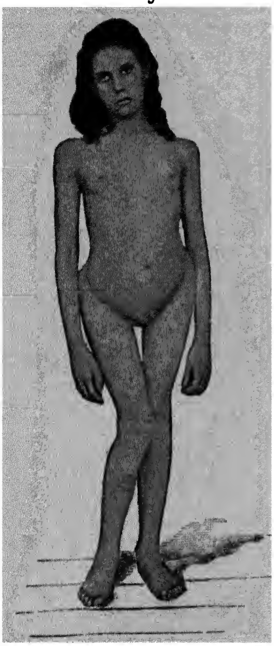


FIG. 169

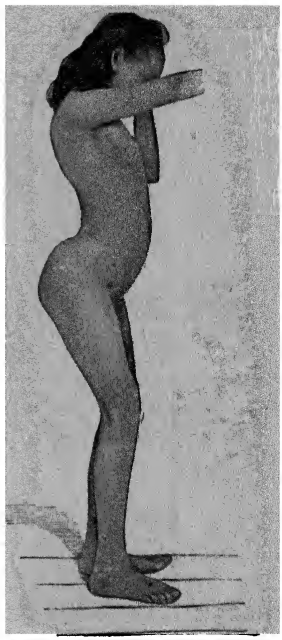


FIG. 170.

CONGENITAL DISLOCATION OF BOTH HIPS IN A GIRL OF FIFTEEN YEARS, SEEN FROM THE FRONT AND SIDE. (FROM PHOTOGRAPHS KINDLY LENT BY MR. J. JACKSON CLARKE.)

in boys. It may pass unnoticed until the child begins to walk, and then the characteristic signs become evident. The limb is shortened and flexed on the pelvis, owing to the traction of the ilio-psoas muscle, resulting in a considerable amount of lordosis (Fig. 170), whilst scoliosis is well marked in one-sided cases. Since the head of the femur is displaced from the middle line, a gap is usually noticed between the thighs close to the perineum. Considerable adduction of the lower end of the femur is present (Fig. 169), and

in bilateral cases a scissor-leg deformity may ensue. The patient's gait is of a curious waddling character, which becomes very marked if one side alone is affected. Since the head of the bone is only maintained in position by its ligamentous and muscular attachments, it can often be drawn down at first, and the leg thus lengthened to the extent of an inch or two; moreover, it is often easy to reduce the displacement and put the head of the bone in the acetabulum in children that have not walked much. At a subsequent date strains to the limb are almost entirely borne by the ligamentous tissues, and hence attacks of synovitis are common.

Pathological Anatomy.—*At birth* no true dislocation is present, but there is an ill-developed condition of the upper end of the femur and of the acetabulum, especially of the posterior and upper lip, as a result of which true dislocation occurs as soon as walking is

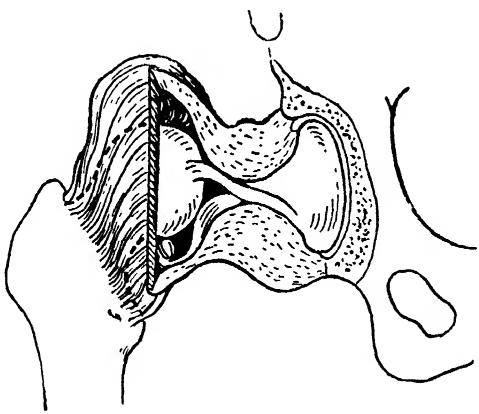


FIG. 171.—DIAGRAMMATIC SECTION OF CONGENITAL DISLOCATION OF HIP, SHOWING THICKENING OF CAPSULE, AND LENGTHENING OF ROUND LIGAMENT. (HEY GROVES.)

attempted. The cervico-diaphysial angle is often increased, so that a condition of coxa valga is not uncommon, and the angle of torsion of the neck on the shaft is usually greater than normal. The want of pressure upon the head, due to its displacement, results in defective growth, so that after a while the head becomes stunted. *After the child has walked*, the head becomes more and more displaced, so that finally it may lie well above the acetabulum on the dorsum ilii (R.S., Fig. 3), and is often much deformed. The capsule becomes stretched and is thicker than usual, especially midway between its bony attachments, where the joint cavity is represented by a narrow isthmus, through which it is impossible to replace the head (Fig. 171); the ligamentum teres is elongated. The acetabulum becomes triangular in shape, owing chiefly to want of growth of the iliac portion; the muscles around adapt themselves to the modified

arrangement of the parts. The ultimate result in all cases where the deformity remains untreated, as well as in many that are reduced, is the development of a somewhat severe type of osteo-arthritis about the age of thirty years.

It is obvious that the results depend much on the **early diagnosis** of the condition before the child has walked. This is effected best by noticing that the movements of the hip are abnormally free, especially internal rotation, whilst the existence of a sort of crackling or click which occurs spontaneously when the child is throwing about its leg, especially in adduction, should suggest a more careful examination. After walking, there is not much difficulty in detecting the presence of this deformity.

Treatment is commenced as soon as a diagnosis has been made, since if it be undertaken before the patient has walked it is much easier and more likely to be successful. Reduction is effected under a general anæsthetic. The pelvis is steadied by an assistant, and the thigh fully flexed and abducted. If now traction is made on the limb and pressure forwards exerted with the fingers upon the great trochanter, the head may be felt to slip into the acetabulum with a characteristic click. This manœuvre is repeated more than once to make sure of its efficiency. The limb is then put up in plaster of Paris in the fully abducted and flexed position, and this is maintained for ten or twelve weeks. After this interval the plaster is removed, and if all is satisfactory the limb is again immobilized in plaster, but in a slightly less abducted position; and the same process is repeated at gradually diminishing intervals until in about eight months' time it is possible to do without the plaster, and the child may be educated in walking.

If, however, the child is not brought under observation until it has walked or is three or four years old, considerable difficulty will arise in effecting reduction owing to the contraction of muscles, especially the flexors and adductors, and to the changes which have taken place in the capsule. The flexors will have to be stretched by hyper-extension, and the adductors may even need to be ruptured or their attachment to the pubis severed. Considerable pressure may have to be used in order to enable the head of the femur to push through the contracted portion of the capsule and reach its proper position in the flattened acetabulum. Otherwise the treatment is the same as for the younger children.

In children between six and eight years of age, treatment by *open operation* can be considered if manipulative treatment has failed. The limb is previously manipulated and stretched, so that it can be kept fully abducted for a few weeks. The joint is then opened from in front by the usual anterior incision, carried up perhaps over the front portion of the crista ilii. The psoas tendon may require to be notched or divided. The small isthmus of communication between the anterior unoccupied portion of the joint and the posterior compartment where the head of the bone resides is dilated and freely enlarged, if need be, by incision, and the head

is then replaced in the acetabulum by manipulation. The capsule is carefully closed, and the operation is completed, if possible, by attempting to constitute a new upper lip to the acetabulum by turning down an osteo-periosteal flap from the ilium, strengthened perhaps by a bone graft, with the free edge attached to the upper and back part of the capsule. The limb is maintained in the abducted position for six or more months, and only gradually restored to the normal, but the child is allowed to walk on it, unless very fully abducted, at the end of six or eight weeks.

In older children where reposition has failed, or is impossible owing to secondary anatomical changes, it may be possible to drag the head of the bone more or less into position, forcing it rather forwards towards the neighbourhood of the anterior superior spine, and then, without opening the joint, to form a new bony lip as indicated above, so as to retain it there.

Young adults or children over fourteen years of age, where operative treatment is useless, must be fitted with a high boot.

Coxa Vara, or incurvation of the neck of the femur (Fig. 172), is a condition in which the neck of the bone, instead of passing obliquely upwards, is horizontal, or in bad cases directed downwards, whilst shortening from interstitial absorption also occurs, and the head becomes mushroom-shaped. At first the osseous tissue is softened, but after a while sclerosis supervenes. It is met with in children as a result of rickets, or perhaps more frequently in young adults, when it is sometimes due to the adolescent form of the same disease. Certainly it is seen most frequently in those who have to do much walking or carrying of heavy weights. In some cases it results from a gradual slipping down or traumatic separation of the epiphysis, which constitutes the head of the bone, or from a fracture of the neck in a child, followed by yielding of the callus (R.S., Fig. 22). In elderly people it is sometimes due to arthritis deformans.

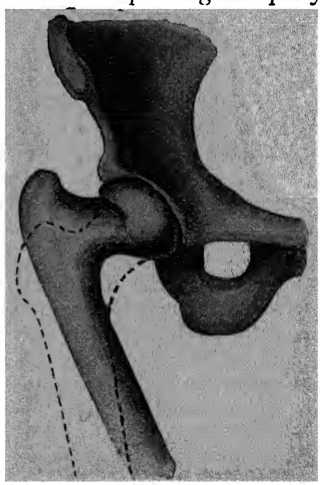


FIG 172.—COXA VARA.
The dotted lines represent the normal neck of the femur.

The **Symptoms** commence with pain in the region of the hip, followed by a distinct limp. As the neck of the bone becomes absorbed or curved, the trochanter rises above Nélaton's line, and real shortening of the limb occurs, even up to $1\frac{1}{2}$ inches. The limb is also everted and the trochanter increasingly prominent, especially on flexing the thighs. Internal rotation and abduction of the joint are limited, the latter being practically impossible in the more severe cases, owing to the base of the trochanter hitching against

the lip of the acetabulum. On flexing the limb, the thigh sometimes lies across the sound one, whilst in the later stages the adduction may be so marked as to constitute a scissor-legged condition. As distinguishing features may be mentioned: the absence of local swelling or tenderness on pressure, as also of the up-and-down movement on traction, so well marked in congenital dislocation, whilst suppuration never follows, and thickening of the trochanter is not observed.

Treatment.—In the early stages rest is *the* essential, and thereby any increase in the deformity already existing is prevented; local massage and manipulation are also advisable, whilst in children prolonged extension with inversion may do good. In the later stages, subtrochanteric osteotomy, in order to alter the axis of the bone, is perhaps the best measure to undertake, although a cuneiform osteotomy of the neck is recommended by some. The subsequent shortening may be dealt with by means of a thick sole on the under surface of the boot.

Coxa Valga is the term applied to the opposite deformity, in which the axis of the neck of the femur approaches more to that of the shaft, and the angle of inclination between the two is greater than the normal 125°. It is usually secondary to congenital dislocation or infantile paralysis, and largely due to the absence of the transmission of the body-weight. The limb is generally abducted and rotated outwards, and there is some limitation of adduction and internal rotation. The trochanter is flattened and displaced below Nélaton's line. **Treatment,** if necessary, is usually directed to the cause; but if the resulting limp is seriously noticeable, a subtrochanteric osteotomy may be desirable.

A **Clicking Hip** is a troublesome affection in which, when the thigh is moved in certain directions (usually flexion with slight inversion), some deep structure slips over the back of the great trochanter with a snap or crack, and possibly some slight pain. As a rule the structure affected is the tendon of the gluteus medius or the iliotibial band of fascia, and most patients are able to carry on their occupations without difficulty, unless called on to undertake heavy walking or severe exercise. Where treatment is necessary, an incision may be made over this hip, for choice under a local anæsthetic, so that the patient may be able to use the joint and demonstrate the actual lesion. The tendon or fascial band thus identified usually requires division and shortening, or re-fixation to the bone in a new position so as to steady it effectively.

Congenital Affections of the knee are mainly connected with the patella, which is sometimes absent, and then other deformities are associated with its non-development. The extensor tendon passes down the front of the knee as a thick band, and the function of the joint is not much impaired.

Congenital Dislocation of the Patella may be present as a persistent lesion, the bone lying to the outer side of the joint; but more commonly the displacement only occurs at intervals. (See Recurrent Dislocation of Patella, p. 705.)

Genu Valgum, or *knock-knee*, is a deformity in which, if the knees are allowed to touch with the patellæ looking forwards, the malleoli are separated one from the other—*i.e.*, it is a condition of fixed abduction of the legs from the middle line, with some external rotation (Fig. 173). One or both limbs may be affected, but if due to general causes the double form is more common. Occasionally genu valgum occurs in one leg, whilst the other is in a condition of genu varum.

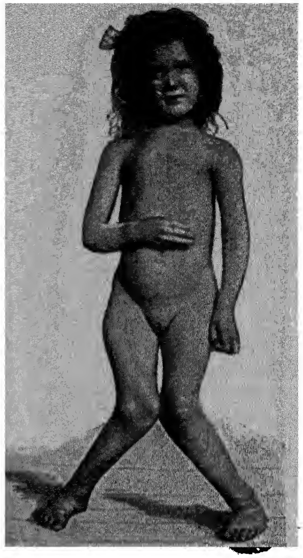


FIG. 173 —GENU VALGUM OF RACHITIC ORIGIN.

The patient was a child aged twelve years. The femora were curved antero-posteriorly, but radiography demonstrated that the trouble in the right leg was as much tibial as femoral in origin. Cuneiform osteotomy of both tibia and femur was needed on the right side, whilst simple osteotomy of the femur sufficed to correct the left side.

There are two main **varieties** of the disease, viz : (1) The rachitic genu valgum of young children, and (2) the static form occurring in adolescents.

The genu valgum of young children arises from the irregular epiphyseal development induced by *rickets*. Increased growth occurs on the inner side of the joint, and this may involve equally the femur and tibia, although most frequently the former is mainly affected. When once the axis of the limb is altered, the weight of the trunk transmitted chiefly through the outer portion of the joint tends to increase the deformity. In not a few cases an antero-lateral rachitic curvature of the diaphysis of the femur is an important element.

The static genu valgum of adolescents occurs most commonly in young people of relaxed constitution, and particularly in those who have to carry heavy weights. Thus, anæmic girls who act as nurse-maids, and young bricklayers, smiths, and porters, are very liable to it. The method of origin is probably as follows: In the erect posture the femur is normally set at an angle to the tibia (which is vertical) in such a way that the weight of the trunk passes rather through the outer than the inner condyle, whilst the latter structure is lengthened in order to keep the plane of the knee-joint horizontal. This position naturally throws a certain amount of strain and tension on the internal lateral ligament, even in a healthy person (hence its insertion into the shaft and not merely into the upper epiphysis of the tibia); and this strain is increased when the natural position of rest—*i.e.*, with the feet separated and slightly abducted—is adopted A long continu-

ance of this posture tires those muscles on the inner side of the limb which tend to counterbalance this strain, especially if a certain amount of additional weight has to be carried, and particularly in those whose bones have rapidly increased in length and weight without any coincident increase in power of muscles or ligaments. Hence the internal lateral ligament becomes more and more stretched, and not unfrequently a certain amount of lateral mobility of the knee is noticed in the early stages. Subsequently the outer condyle becomes atrophied from more weight being transmitted through it, and the inner condyle becomes lengthened from overgrowth. Flat-foot and lateral curvature of the spine often accompany this form of genu valgum.

Occasionally genu valgum is due to *traumatic causes*, such as fracture of the tibia or femur close to the joint, or lateral dislocation of the knee; whilst, again, it may be caused by atrophy consequent on interference with the epiphysis from local injury or diseases other than rickets. It is sometimes observed, as a result of riding, in those with long legs, as in cavalry soldiers; short-legged individuals, such as jockeys, are more liable to develop a condition of genu varum.

The **Physical Condition** of the parts about the knee may be summarized as follows: (*a*) The inner condyle of the femur is elongated and prominent; the increase in size is mainly in the vertical and transverse directions, and but very little antero-posteriorly, so that, on flexion of the joint, the deformity to a large extent disappears; (*b*) impaired growth and atrophy of the outer femoral condyle and tibial tuberosity are present owing to the weight of the body being transmitted more directly through these structures; (*c*) relaxation of the ligamentous and muscular tissues takes place on the inner side of the joint; this, however, is not constant, especially in the later stages, or in cases which are stationary; (*d*) the tendons and ligaments on the outer aspect of the joint are contracted and shortened, especially the external lateral ligament, the ilio-tibial band, and the tendon of the biceps; (*e*) the patella tends to be thrown outwards, and in bad cases recurring dislocation is sometimes observed; (*f*) in rachitic cases a localized bony outgrowth can often be detected on the inner surface of the tibia about 2 or 3 inches from the joint, and is probably due to a localized periostitis at the point of attachment of the internal lateral ligament.

The feet are displaced outwards, or occasionally inwards, as best suits the convenience of the patient in obtaining as good a footing as possible; the bones of the legs and of the thighs are often bent; and, if the condition is unilateral, scoliosis may result. In well-marked cases the gait of the patient is of a rolling or waddling type, and very characteristic; the legs are partially flexed, and as the condyles touch or overlap they have to be separated at each step to allow of progression.

Treatment.—In *rachitic* cases, the infant requires the adoption of dietetic and therapeutic measures suitable to the condition present. For the local deformity absolute rest in bed is enforced; the limbs

are well rubbed daily, and such manipulation and pressure employed as will help to straighten the limb. By perseverance slow but appreciable progress may be made until the deformity is corrected. In older children, splints may be applied on the outer side of the limbs, reaching from the waist or axilla down to the outer malleoli, or, if they are to be kept off their feet, beyond them. These are retained in position by water-glass bandages, put on firmly enough to draw the knees outwards. Such an arrangement is often sufficient in early cases to bring about a cure in the course of a few months.

In *static* cases the administration of tonics, such as iron and arsenic, combined with rest, massage, and possibly a change of air, will frequently suffice to determine a cure in the early stages. Suitable apparatus must be adopted when the patient is allowed to walk; that usually employed consists of a walking calliper (Fig. 252), jointed at the knee, and fixed below into a slot in the heel of a well-made boot, and attached above to a pelvic band.

When, however, the osseous deformity is fixed, and the patient of such an age as to preclude the hope of a cure by mechanical means, *osteotomy* will be required, and the operation devised by *Macewen*, or some modification of it, is that generally employed. It consists in the division of the femur transversely about a finger's breadth above the upper border of the external condyle, so as to be well away from the epiphyseal cartilage. Macewen himself used an osteotome* for the purpose, introducing it through an incision made ½ inch in front of the tendon of the adductor magnus, and turning it so as to lie at right angles to the long axis of the shaft; the bone is divided for three-quarters of its diameter, and the remainder is broken. A similar method may be employed from the outer side, the force used in breaking the inner layer of compact bone comminuting and compressing that portion, and so diminishing the deformity. Many surgeons, however, prefer to divide the bone with a saw, previously making a track for it along the front of the femur, and such an operation is certainly simple and efficacious. The limb, having been straightened, is either put up at once in plaster of Paris, or, perhaps, at first in a Gooch's splint, which allows the wound to be looked at and dressed, and subsequently in plaster. Union is complete in six weeks, but an immovable apparatus should be kept on for three months.

Genu Varum is a less common condition, characterized by a fixed separation of the knees when the ankles are in contact (Fig. 174). It arises from three chief causes: (i.) Occupation, and particularly that of a jockey, the short legs being constantly apposed to the sides of the horse; (ii.) traumatism, especially if directed to the femoral condyles; and (iii.) rickets, the lesion usually present being a well-marked excurvation of the femoral shafts, with possibly a similar curve of the tibiæ (*bow-leg*). The condition is usually bilateral and symmetrical, but occasionally one side only is affected,

* An *osteotome* differs from a *chisel* in the fact that the former is bevelled on both sides, whilst the latter is merely bevelled on one side.

(R.S., Fig. 30) participate in this deformity, or are separately affected; the antero-posterior curve is usually increased (Fig. 175), and some amount of abduction or adduction may also be present. The bones in these cases are flattened from side to side, presenting a sharp edge in front, with a buttress-like support or strut reaching along the concavity; in time they become exceedingly dense and sclerosed.

Treatment in the early stages consists of rest and constitutional treatment, and in the application of suitable apparatus to reduce the deformity. Where the femora are seriously affected, it may be necessary to provide the patient with an apparatus (*e.g.*, a hinged double Thomas's knee-splint) which fits closely round the pelvis, and carries the weight to the ground by lateral metal rods which also maintain continuous extension. In the worst cases operation will be required, but never until all signs of active disease have passed. The bones may be divided at their most prominent parts, or, if necessary, a wedge-shaped portion may be removed (*cuneiform osteotomy*), the sections being made at right angles to the upper and lower segments of the bone respectively. Careful and prolonged after-treatment, including the use of suitable splints, is required, especially where the femora have been divided, in order to prevent a reappearance of the deformity.

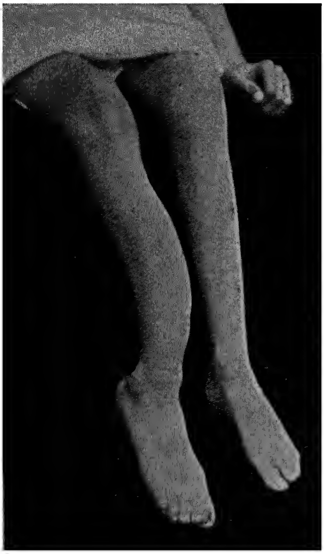


Fig. 175.—Rachitic Deformity of Bones of Right Leg

The tibia and fibula also become distorted and curved antero-posteriorly as the result of *inherited syphilis;* this usually comes under notice at a later date than the rachitic change, and is due to a deposit of new bone under the periosteum rather than to bending. The deformity is purely antero-posterior, without lateral deviation, whilst the subcutaneous margin of the tibia is rounded, and not sharp as in rickets. Moreover, the curve generally involves the centre of the bone, whilst in rickets the chief deformity occurs either near the knee or a little above the ankle.

Deformities of the Feet.

These cannot be understood properly unless the student grasps clearly the mechanical structure of the foot. It has a twofold purpose. (1) to form a solid and firm basis of support for the body; and (2) to permit of elasticity and

spring in the gait. The foot therefore consists of two parts: (1) the solid posterior portion (astragalus and os calcis) through which the weight is transmitted from the leg to the heel; and (2) an anterior segment comprised of the front half of the astragalus and all the remaining bones, set at varying angles (to break up shock), and with movable toes controlled by muscles. Elasticity is also secured by the arches of the foot, which are threefold: (1) The internal longitudinal arch (arch of the instep), which reaches from the heel to the head of the first metatarsal and varies much, but in a well-formed foot is sufficiently pronounced to keep the skin clear of the ground; it is this arch which suffers most in 'flat-foot.' It is maintained chiefly by the inferior calcaneo-scaphoid or 'spring' ligament upon which rests the under side of the head of the astragalus; beneath the ligament passes the tendon of the tibialis posticus which gives slips to most of the tarsal bones. The long and short plantar ligaments and the short muscles and deep fascia of the foot also assist in maintaining the arch. (2) The external longitudinal arch is of slight importance, inasmuch as the constituent elements (os calcis, cuboid, fourth and fifth metatarsals) rest almost always on the ground. (3) The transverse arch is the necessary result of the arrangement of the two longitudinal arches extending from the astragalus to the heads of the metatarsal bones, and varies in its degree with the height of the instep; should this be lost, the transverse arch must obviously disappear. It is chiefly maintained by the peroneus longus tendon.

Talipes.

By talipes, or club-foot, is meant a deformity of the foot due to muscular, ligamentous, or osseous causes, the displacement occurring mainly at the ankle and mid-tarsal joints; it may be either congenital or acquired.

The *congenital* variety is often hereditary, and may be found in several members of the same family; it is sometimes associated with other deformities, such as hare-lip and spina bifida. It may arise from malformation of some of the bones of the foot, or of the lower end of the tibia or fibula; but probably it is more commonly due to malposition of the feet *in utero* induced by an unusually small uterine cavity or a deficient amount of liquor amnii, as a result of which the feet are abnormally compressed and held in one position.

The *acquired* varieties arise from some derangement of the equilibrium normally maintained between opposing groups of muscles, in consequence of which the more powerful group draws the foot into an abnormal position. Thus it may be due to: (*a*) *Paralysis*, the result of infantile palsy, or of peripheral nerve lesions: (*b*) *Cicatricial* contraction of muscles from diffuse suppuration. Thus penetrating wounds, followed by suppuration of the gastrocnemius or soleus, often cause such a degree of cicatricial contraction as to constitute a talipes equinus, whilst necrosis or caries of the tibia may lead to such changes in the tibialis anticus or posticus as to determine a position of talipes varus. (*c*) Essential muscular shrinking, resulting from a chronic myositis fibrosa, is occasionally met with in elderly people. (*d*) It also occurs in *spastic* paralysis (p. 526). (*e*) Shortening of the leg from hip or knee mischief often induces a *compensatory* talipes equinus, whilst injuries or diseases of one of the epiphyses of the leg bones may stop its growth, and then the continued development of the other bone forces the foot to one side or the other.

(*f*) **Finally**, prolonged maintenance of the foot in a bad position may lead to permanent deformity, as in the variety known as talipes decubitus.

Four primary forms of talipes are described, viz.: **T. Equinus,** in which the heel is drawn up, the patient walking on the toes (plantar flexion); **T. Calcaneus,** in which the toes are raised from the ground (dorsiflexion); **T. Varus,** in which the anterior half of the foot is adducted and inverted, and the inner side of the foot is raised, the patient walking on the outer; and **T. Valgus,** due to abduction and eversion of the anterior half of the foot, or to yielding of the longitudinal arch on the inner side. Not unfrequently mixed forms occur, due to the association of two of the above—*e.g.*, T. equino-varus, or T. equino-valgus, or T. calcaneo-valgus.

As to the *relative frequency* of these different forms, there is not the slightest question that T. equino-varus is by far the

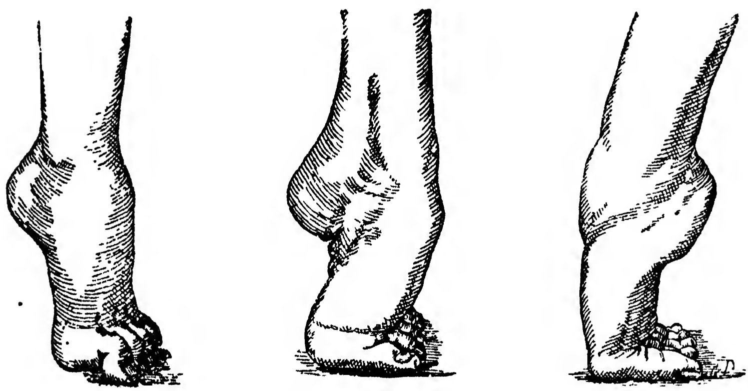


FIG. 176.—VARIOUS FORMS OF TALIPES EQUINUS.

commonest. If, however, we exclude congenital cases and flat-foot, T. equinus is in all probability the variety most frequently observed.

Talipes Equinus (Fig. 176, A, B, and C) is almost always acquired; as a congenital lesion it is very uncommon. It is a very frequent sequela of gunshot wounds of the muscles of the calf, which have been followed by suppuration or required partial excision for gas gangrene; cicatrization naturally draws up the heel and brings about this deformity. It also occurs as a compensatory manifestation where the limb has been shortened, as after hip disease, and may follow the prolonged pressure of bed-clothes on the dorsum of the foot of a bed-ridden patient (T. decubitus). The paralytic form is the result of any lesion of the nerve-fibres which control the anterior tibial group of muscles, and if these are divided above the anterior tibial nerve, the peronei muscles are also likely to be involved, and the

deformity has an element of varus added to the 'drop-foot' which follows. When resulting from poliomyelitis, the muscular involvement may be a little less regular in its distribution. In both of these conditions the equinus deformity is of the flaccid type.

In the slightest cases all that is noticed is that the foot cannot be dorsiflexed beyond a right angle (right-angled contraction of the ankle). When more marked, the heel is drawn up, and the patient walks on the heads of the metatarsal bones and on the toes, which are usually hyper-extended, but may occasionally become flexed (Fig. 176, C), so that in time the whole dorsum of the foot may even be turned downwards.

Secondary changes occur in old-standing cases. The astragalus is displaced forwards from under the malleolar arch, only the posterior part of the articular surface being in contact with the tibia. In the paralytic type the anterior segment of the foot drops at the mid-tarsal joint, so that the head of the astragalus and scaphoid

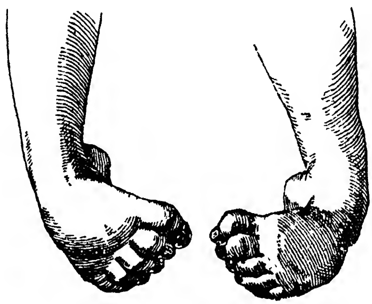


FIG. 177.—DOUBLE TALIPES EQUINO-VARUS OF CONGENITAL ORIGIN.

constitute a marked prominence beneath the skin. In all cases the sole of the foot is liable to be shortened by contraction of the plantar fascia and of the short plantar muscles (pes cavus), and a certain amount of varus is frequently present. In this, as in all forms of talipes, callosities, and perhaps bursæ beneath them, form over points of pressure—viz., under the heads of *all* the metatarsal bones.

Talipes Varus, or, as it is most frequently termed, **Equino-varus,** is the commonest variety of congenital club-foot, and is then often bilateral, and may be accompanied by other congenital defects—*e.g.*, hare-lip or spina bifida. As an acquired deformity, T. varus is not a very unusual result of infantile palsy affecting the extensor and peroneal muscles, although the equinus element usually predominates; other cases are due to a spastic contraction of these muscles.

The heel is drawn up, and the anterior half of the foot adducted

and drawn inwards (Figs. 177 and 178). The inner border of the foot is concave, and a well-marked transverse crease crosses the sole on a level with the mid-tarsal joint; the outer border is convex, and in adults who have walked a thick bursal formation is usually present over the cuboid (Fig. 179). In neglected cases the patient may even stand on the dorsal aspect of the latter bone (Fig. 180). The sole of the foot is arched from secondary contraction of the plantar fascia and short muscles of the sole, and a longitudinal crease may run down the centre of the sole, owing to doubling over of the outer metatarsal bones.

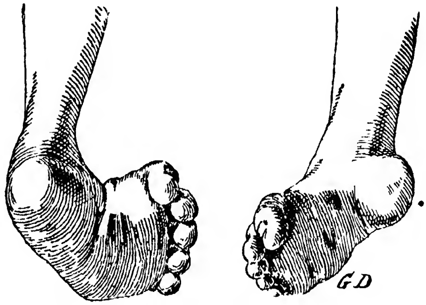


FIG. 178.—DOUBLE TALIPES EQUINO-VARUS OF CONGENITAL ORIGIN, SEEN FROM BEHIND.

The most marked *anatomical changes* in the congenital type are found in the astragalus, the neck of which is elongated and inclined inwards; the bone also projects forwards from under the tibio-fibular

FIG 179.—CONGENITAL TALIPES VARUS OF MANY YEARS' DURATION

The large bursæ on the outer sides of the feet induced by walking are very noticeable.

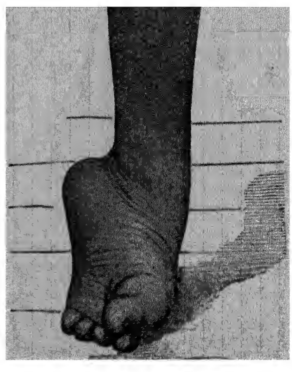


FIG. 180.—VERY NEGLECTED CASE OF TALIPES VARUS.

arch, the posterior portion of the upper articular facet alone remaining in contact with it. The scaphoid is displaced to the inner side of the head of the astragalus, and its tubercle is usually in close proximity to, or may even touch, the inner malleolus. The os calcis and other tarsal bones are also modified in position and shape to

correspond with these changes. The dorsal tendons are displaced inwards, usually occupying the centre of the concavity between the foot and the leg. The ligaments on the inner side of the foot are contracted, especially the anterior portion of the deltoid, the inferior calcaneo-scaphoid, and to a less extent the long and short plantar ligaments.

The following table indicates the chief diagnostic points between congenital and paralytic T. equino-varus:

	Congenital.	*Paralytic.*
HISTORY	Affection has existed from birth.	Affection not developed till the second or third year, and ushered in by convulsions, fever, etc.
FEET AFFECTED	Usually bilateral.	More often unilateral.
CIRCULATION	Good.	Feeble; limb is sometimes cold, blue, and clammy.
MUSCLES	But little wasting.	Extreme wasting.
ELECTRICAL REACTIONS	Not much impaired.	Almost entirely absent in paralyzed muscles.
GROWTH OF BONES. ..	Much as usual.	Considerably diminished.
CREASES IN SOLE	Present.	Absent.

Talipes Calcaneus is an unfrequent variety of the deformity, and may be either congenital or acquired. In the *congenital* form (Fig. 181) the toes are drawn upwards so that the heel alone comes into contact with the ground, the sole pointing forwards. The

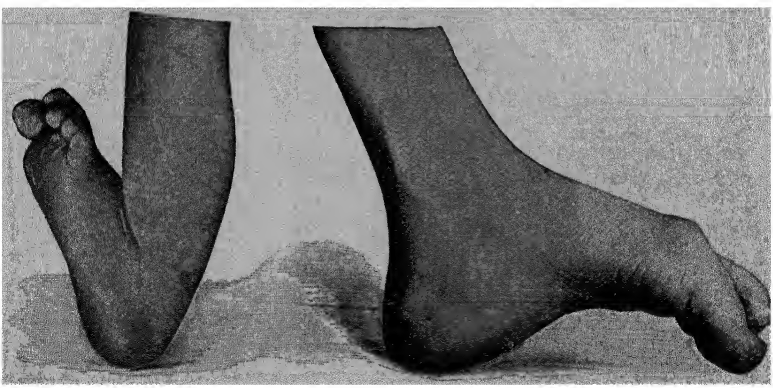


FIG. 181.—CONGENITAL TALIPES CALCANEUS.

FIG 182.—PARALYTIC TALIPES CALCANEUS WITH WELL-MARKED HALLUX FLEXUS.

extensor tendons are contracted, but the toes may be flexed owing to the tension of the flexor longus digitorum. It is sometimes associated with deviation of the foot inwards or outwards, constituting a condition of T. calcaneo-varus or -valgus. The *acquired* variety (Fig. 182) is generally due to infantile palsy of the calf

muscles, or occasionally to overstretching of the tendo Achillis after tenotomy. The longitudinal arch of the foot is increased (pes cavus), partly from the development of a large pad of fat over the calcaneal tuberosities, but mainly from the dropping of the anterior half of the foot from the mid-tarsal joint.

Talipes Valgus is a condition seldom met with as a *congenital* deformity, except in association with T. equinus. In it the foot is abducted and everted, owing to contraction of the peronei muscles. The sole becomes flattened, and the inner border of the foot comes in contact with the ground (Fig. 183). Considerable pain is usually experienced after walking a short distance. This deformity is occasionally due to absence of the fibula. The *acquired* variety, which is not uncommon (Fig. 184), results from paralysis of the tibial muscles, or from spastic contraction of the peronei, the condition in these cases closely simulating flat-foot.

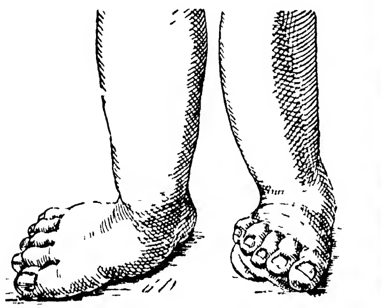


Fig. 183.—Talipes Valgus (Congenital), with a Little Tendency to Calcaneus.

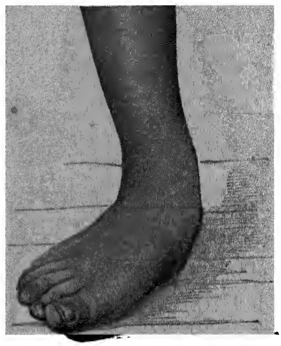


Fig 184.—Paralytic Talipes Valgus.

The **Diagnosis** of the different varieties of talipes is, as a rule, easily made, although the cause of the deformity is not always so readily ascertained. In *paralytic* cases the limb is generally atrophied, bluish in colour, and feels cold and clammy. Trophic lesions are not uncommon in the form of recurrent ulceration, and even ulcers of the perforating type may develop, especially in cases due to peripheral nerve lesions. The trouble is often unilateral, and the muscles are wasted and flabby. In *congenital* cases the condition is usually symmetrical, and of course present from birth; considerable resistance is felt on any attempt being made to correct the deformity, and the limbs look healthy, are well nourished, at any rate at first, and free from trophic lesions. In *spastic* cases (most frequently T. equinus) spasm or contraction of other parts is usually present, which renders the diagnosis obvious; one or both limbs may be affected; the reflexes are exaggerated; the gait is characteristic; and the muscles, at first firmly contracted, may finally atrophy.

The **Treatment** of talipes is always tedious, demanding care and

patience on the part of all concerned. It is important to discriminate accurately between the different varieties, and to recognize the actual anatomical lesions present in each.

Talipes equinus, if secondary to hip disease, should not, as a rule, be interfered with. When likely to develop as a result of intrinsic muscular contraction (post-suppurative or otherwise), it may be prevented (or even cured in an early stage) by the use of what is known as Sayre's apparatus (Fig. 185). This consists in the application of a plantar splint which projects well beyond the toes, and from the anterior end of which a piece of adhesive strapping is carried to just below the knee, to which it is applied and fixed by a firm bandage. Each day the bandage is carried a little lower down the limb, and as the traction of the strapping is thereby increased, the foot is gradually extended. When fully developed. tenotomy of the tendo Achillis (p. 468) may be required, accompanied if necessary by division of the plantar fascia, whilst in neglected cases, or where tenotomy has failed, excision of the astragalus gives excellent results, the patient being able to walk subsequently with a plantigrade foot.

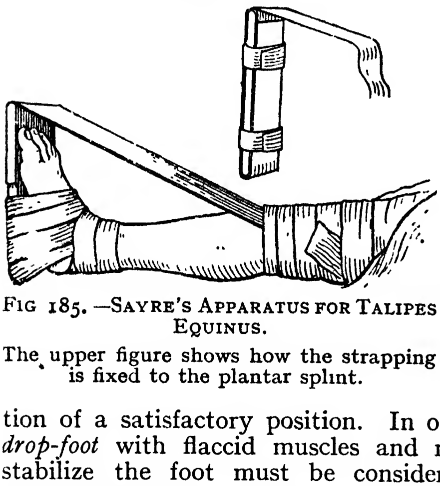


FIG 185.—SAYRE'S APPARATUS FOR TALIPES EQUINUS.

The upper figure shows how the strapping is fixed to the plantar splint.

In the *paralytic* variety, whether central or peripheral, every effort must be made to conserve and render more efficient all muscular tissue that is capable of functioning, and thus massage and electricity are required and the adoption of a satisfactory position. In old-standing helpless cases of *drop-foot* with flaccid muscles and relaxed joints, operations to stabilize the foot must be considered, and a sub-astragaloid arthrodesis seems to be the most satisfactory means of securing this. The ankle-joint itself is not stiffened, but the patient wears an external iron, and thereby stability is secured. Other surgeons prefer Whitman's operation, which consists in removing the astragalus through an incision on the outer side of the foot. The foot is then displaced slightly backwards, and the malleoli fitted into suitable beds prepared on the inner side in front of the sustentaculum tali, and on the outer by gouging out a hole in the os calcis or cuboid. When healed, a considerable degree of stability is secured, and with the aid of a surgical boot walking is possible.

Congenital T. equino-varus.—As already indicated, treatment should be commenced as soon after birth as possible, and the intelligent co-operation of both mother and nurse must be secured. Two or three times a day the infant's foot must be firmly manipulated

into as good a position as possible and held there for some minutes. The surgeon will undertake the same once or twice a week with a little more energy. The object aimed at must be clearly appreciated —viz., firstly, to overcome the cavus element, then to abduct and evert the foot, and finally to remedy the equinus position.

When the child is from three to six months old, it is possible to apply a plaster retentive dressing, and hence if by that time simple manipulation has not succeeded in overcoming the deformity, a definite attempt must be made under an anæsthetic to correct it, but only by manipulation. The foot is then put up in plaster with the knee at a right angle, the plaster reaching to the mid-thigh with changes for movements once a fortnight. In most children under twelve months of age this treatment is successful, though in a few division of the tendo Achillis may be required.

If the case is very resistant or is not brought to the surgeon till later (one to three years), when bony growth tends to fix the deformity, it may be necessary to attempt *forcible correction* under a general anæsthetic by the employment of Thomas's wrench (Fig. 189), applied over a suitable packing of wool. Failing this, subcutaneous or open division of the anterior portion of the deltoid or internal lateral ligament of the ankle may be required, as also of part of the inferior calcaneo-scaphoid ligament; the tibialis anticus and posticus tendons may also need division. Subcutaneous elongation of the tendo Achillis is the final step of the corrective operative treatment, but it must be noted that this is not necessarily all undertaken at one sitting. Plaster of Paris cases are applied until the foot remains in a good position without pressure, and then a metal malleable splint or tin night-shoe (Fig. 186) is applied. Massage and passive movements are required, and later on education in walking.

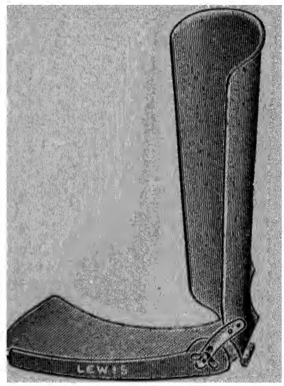


Fig. 186.—Tin Night-Shoe Useful in Cases of Talipes with Movements Possible in Various Directions.

When the child does not come under observation until the deformity is fixed, and still more when the foot has been used in its bad position for walking, operations directed to the bones will be required. In the less severe cases, division of the neck of the astragalus may be undertaken from the dorsal aspect, and the os calcis can be divided just behind the calcaneo-cuboid joint, together with such section of tendons and ligaments as may be required. In the worst cases, however, *cuneiform tarsectomy* or removal of a wedge-shaped portion of the tarsus, with its base outwards, and regardless of exact anatomical details, must be performed. This is accomplished through a semilunar incision on the outer side of the foot; the thick subcutaneous structures, including the bursa, are

removed, and the extensor tendons, already somewhat displaced inwards, are stripped from the bones and held aside. The tarsus is divided by a chisel in two places so as to include a wedge with its base outwards; the lines of section are as far as is possible at right angles to the anterior and posterior segments of the foot, and sufficient bone is taken away to permit the foot to come into good position without difficulty. After closing the wound an ordinary removable splint is applied at first until the wound is healed, and then a plaster case is employed for six or eight weeks. The results are excellent, the foot, although a little shortened, being firm and plantigrade.

In *paralytic T. varus* of central origin, with persistent paralysis of the peronei muscles, it will often suffice to transplant the healthy active tendon of the tibialis anticus from the inner side of the foot to the outer, implanting it in the cuboid, to which it is firmly sutured with the foot everted and dorsiflexed; it is maintained in this position by means of plaster of Paris for six weeks. If this is not sufficient, Whitman's operation (p. 511) must be used, and leg-irons provided.

In congenital *Talipes calcaneus* all that may be needed is division or lengthening of the extensor tendons; but in the paralytic variety some form of apparatus must always be worn. Where the tendo Achillis is thin and attenuated, a portion of it may be excised, and the ends united by suture; or the tubercle of the os calcis into which the latter is inserted may be sawn off and re-attached by a nail or peg to the bone at a lower level (Walsham); but the prognosis in all forms due to paralysis is unsatisfactory.

Talipes valgus must be treated along the same lines as a flat-foot (*q.v.*). If unrelieved by the application of suitable boots, division of the peroneal tendons may be required, or in severer cases wrenching the foot into position, and fixation in plaster of Paris. Removal of a wedge-shaped portion of bone from the inner aspect of the foot may be undertaken, but is not very successful.

Flat-foot (*syn.:* **Splay-foot** or **Spurious Valgus**) is a condition frequently seen in young adults whose occupation exposes them to overfatigue, or the carrying of heavy weights—*e.g.*, in nurse-girls, shop-boys, and in young recruits. It occurs as a natural condition in many of the negro races, and is more often seen in long than in short feet. It is also not uncommon in women about middle life, especially if called on unexpectedly to take over heavy domestic duties.

Mechanism.—In the majority of cases it is due to relaxation of the structures which keep up the longitudinal arch of the foot, especially of the inferior calcaneo-scaphoid or 'spring' ligament, upon which rests the head of the astragalus. A rapid increase in the length and weight of the skeleton apart from an equivalent increase in strength of muscles and ligaments throws undue strain upon this structure, especially if the patient is suddenly exposed to long hours

of standing or weight-carrying. The ligament stretches, the head of the astragalus sinks, the anterior portion of the foot becomes abducted at the mid-tarsal joint, and the typical splay-foot results. The tibialis posticus is often relaxed or even paretic, and the peronei tendons are in the later stages contracted, but in some cases spasm of the peronei muscles is apparently the primary cause of the deformity Occasionally it is due to a gonorrhœal or septic inflammation of the inferior calcaneo-scaphoid ligament, which becomes relaxed and yields under the weight of the body. In a few cases it results from grosser traumatism—*e.g.*, fracture of the neck of the astragalus, or of the sustentaculum tali, or it may follow a badly treated Pott's fracture. Care must be taken to differentiate flat-foot with tenderness on the inner side of the arch from Kohler's disease due to subacute osteitis of the scaphoid (p. 644); radiographic examination is here helpful.

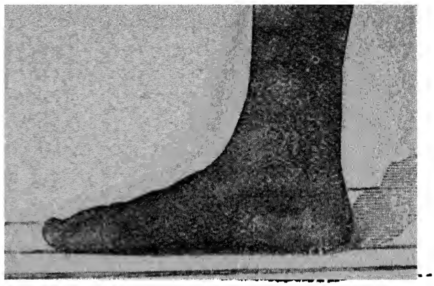


FIG. 187.—FLAT-FOOT.

However produced, the *deformity*, when fully established, is tolerably characteristic (Fig. 187). The sole of the foot is flat, and in well-marked cases comes in contact with the ground throughout the whole of its extent, as indicated by a print of the sole (Fig. 188). The inner border is convex and somewhat lengthened, whilst the anterior half is everted and abducted. The head of the astragalus is felt a little in front of and below the internal malleolus, whilst the sustentaculum tali, which is normally distinguishable about $\frac{3}{4}$ inch below the malleolus, is buried by this displacement. The tubercle of the scaphoid is less evident than usual, being situated below and in front of the head of the astragalus.

FIG. 188.—FOOTPRINTS OF HEALTHY (LEFT) AND FLAT FOOT.

The raised arch of the instep in the healthy foot is represented by the hollow on the mesial side, when the arch is exaggerated (P. cavus), this hollow becomes more distinct, and may actually divide the print into two. In flat-foot it entirely disappears.

In the early stages the foot may appear to be normal or merely a little everted when the patient puts no weight on it; but when he stands, the sinking of the arch becomes evident, and increased pain

is produced. As the condition progresses, the front of the foot is more and more displaced outwards, and the astragalus sinks into the sole. After a time inflammatory troubles are lighted up in the joints, and adhesions form in and around them; or the deformity may become fixed by bony changes. In the early or first stage, therefore, the patient himself or the surgeon can easily restore the foot to a normal position; in the second stage, it may be possible for the surgeon to do so, but probably only under an anæsthetic; finally, in the third stage, when ankylosis has occurred, it is impossible to restore the arch apart from operation.

The subjective symptoms are pain and a sense of weakness and fatigue, especially about the origin of the tibialis muscles, at first only experienced after or during exercise, but subsequently persistent. In the more acute cases, pain is complained of in the sole, and especially below and behind the tubercle of the scaphoid in the situation of the 'spring' ligament; this may be very pronounced before the arch has actually given way. Later, when the bony displacement is becoming more marked, pain across the dorsum is complained of over the astragalo-scaphoid joint; and when the displacement is still more severe, pain on the outer side of the heel may become prominent, probably owing to the outer malleolus impinging on the os calcis. In not a few cases, however, there is but little pain when the arch has totally collapsed. Flat-foot is not unfrequently associated with hallux rigidus (p. 518), and this may be extremely painful.

Treatment.—In the first stage, all that is required in the majority of cases is rest in bed for a few days if the 'spring' ligament is very tender, together with massage; by this means, overstrained ligaments and muscles recover themselves. Tonics may also be administered to improve the general health. If the condition is of gradual onset, it may not be necessary to confine the patient to bed. The most important element in the treatment is the provision of suitable *boots*, which shall assist in keeping the foot inverted and thrown slightly over on to its outer border. The boots should be low-heeled and square-toed, and the inner borders should be straight; the heel must be thickened upon the inner side $\frac{1}{3}$ inch, tapering off to the outer side, and carried forward under the arch for $\frac{3}{4}$ inch further than is usual; a patch $\frac{1}{3}$ inch thick should also be placed on the sole. All boots, shoes, and slippers must be similarly treated, and the patients in bad cases must *never* be allowed to put foot to ground without this support; a few minutes on his feet without support may undo the good work of weeks. The patient must be taught to walk with his toes straight in front of him and with no trace of eversion. Tiptoe exercises with the feet inverted are useful in strengthening the short muscles of the sole, as also massage and electricity. The latter may advisably be employed in the form of galvanic foot-baths, followed after a time by the use of the faradic current. The feet are placed in a shallow bath of warm water, which should just reach the instep. The electrodes are arranged so that the current passing between them traverses the longitudinal muscles of the sole.

The anterior part of the transverse arch can also be treated by passing the current through the foot from side to side at the level of the metatarso-phalangeal joints.

When the affection has reached a later stage, and the deformity cannot be remedied by ordinary manipulation, forcible rectification under an anæsthetic may be employed. The foot is firmly grasped in the two hands or in a Thomas's wrench (Fig. 189), and the anterior portion is forced inwards and backwards in such a way as to draw the scaphoid round the head of the astragalus as a fulcrum, and thus restore the arch. Probably a number of adhesions in the astragalo-scaphoid and other joints will be felt to give way during this manipulation. Tenotomy of the peronei is sometimes required before rectification of the position is possible. The foot is put up in plaster of Paris and kept at rest for some weeks, and then boots are supplied, and graduated exercise allowed. Satisfactory results have followed.

When the deformity cannot be rectified even by wrenching, and weight-bearing is still a source of pain, the patient may be advised to wear a carefully-fitted instep pad (fitted to a plaster cast of the

Fig. 189.—Thomas's Wrench.

The two cross-bars are protected by thick indiarubber, and can be approximated or separated by rotation of the handle. The anterior portion of the foot is firmly grasped between them, one being placed on the dorsal and one on the plantar aspect, and forcible wrenching movements can then be carried out.

foot) to assist in supporting the weight; but it must be clearly understood that this contrivance should never be employed for cases where a cure can be established along the lines laid down above. In mid-life these supports are sometimes extremely useful.

In a few cases with a fixed deformity operative proceedings directed to the bones may be justified. The removal of a wedge-shaped section from the inner side of the foot, and the production of bony ankylosis between the scaphoid and astragalus (as recommended by Ogston), is the only operative procedure worthy of consideration. Prolonged rest and a suitable course of exercises and massage will be required subsequently, whilst an instep pad may still have to be worn.

Loss of the Transverse Metatarsal Arch is a frequent cause of sore feet when walking, and may accompany either pes planus or pes cavus, and is often associated with hammer-toes and hallux valgus. It is due largely to loss of power of the peroneus longus, but a good many other elements enter into its causation. It is characterized by the heads of the metatarsals sinking so as to be brought into contact with the ground, and as a result callosities form under them which are extremely painful. It is often possible to press up the

metatarsals into a normal position and to retain them there by pressure applied transversely around the foot just above the heads, and this can be utilized in **Treatment.** A strip of chamois leather can be made to surround the foot in the position indicated and held there by strapping; or better, an elastic band 2 inches wide can be worn around the foot with or without a pad of rubber placed centrally in the sole; with this can be combined an elastic loop which will serve to keep the big toe in correct alinement. Boots with bars across the sole as in Fig. 190 are also most helpful, relieving the pressure on the painful metatarsal heads. Only when measures such as these fail, need the operations mentioned in the section on pes cavus be considered.

Pes Cavus (Hollow or Claw Foot) is a condition characterized by increased concavity of the plantar arch, so that when the individual stands there is a greater interspace than usual, if not an absolute break, between the impressions produced by the anterior and posterior segments of the foot (Fig. 1[illegible]). Corresponding to the plantar concavity there is a marked dorsal convexity, whilst the toes are generally in a condition to be immediately described as hammer-toe; the heads of the metatarsal bones are unduly prominent below, and callosities often form beneath them, causing considerable pain. The condition is almost always associated with a slight degree of talipes equinus (right-angled contraction), and its method of production from this cause is said to be as follows: The weight is normally carried to the ground mainly through the heel, but also partly through the toes; in these cases it is only transmitted through the toes and front of the foot, and since the anterior extensor muscles are probably weak, the short flexors act at an advantage, and by contracting draw the heel downwards so as to reach the ground, and thus the arch is increased.

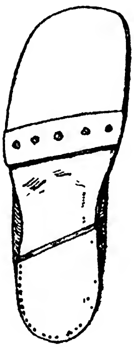


FIG 190.—BOOT WITH CROSS-BAR ON SOLE FOR USE IN PES CAVUS.

In the later stages the foot becomes inverted and assumes a varus deformity: the toes become blue, contracted and painful, and walking becomes almost impossible.

Treatment.—In the early stages when the deformity is slight and easily replaceable, the Achilles tendon should be divided or lengthened (pp. 468 and 469), and the foot put up in plaster in a position of dorsiflexion. When walking is permitted, the boot must have low heels, and a bar should be placed obliquely across the sole so as to rest just behind the heads of the metatarsals (Fig. 190); the object of this is to maintain dorsiflexion, and throw the body-weight on the heel more than on the toes.

In the next stage the heads of the metatarsals begin to project in the sole and become tender. If only the first metatarsal is involved, the trouble may be remedied by detaching the tendon

of the extensor proprius hallucis, drilling a hole transversely through the head of the metatarsal, and threading the tendon through it, finally fixing its divided end to the tendon above so as to constitute a loop which lifts the head of the bone. The plantar fascia will also need division, and perhaps the tendo Achillis, so that the foot can be put up in plaster of Paris in dorsiflexion. Subsequently, boots are supplied as indicated above.

Later on, when the heads of *all* the metatarsals are painful and have callosities beneath them, division of tendons (extensors and flexors) and of plantar fascia may not suffice to remedy the deformity, and then the bones must be shortened. Some authorities recommend excision of an inch or more of the bones close to their bases. I have on several occasions removed an inch or more of the heads of all the metatarsals through dorsal incisions with excellent results and movable joints. After-treatment as before.

In the last and worst stages, astragalectomy may be required to remedy the varus, and amputation of all the toes and heads of the metatarsals may be needed to enable the patient to walk. This is better than amputating the foot, which the patients often desire.

Hallux Rigidus (*syn.:* **H. flexus**) is a painful condition of the great toe, due to a chronic arthritis of its metatarso-phalangeal articulation. It usually occurs in young males with flat feet. The foot is abnormally long; its circulation is defective; the toe itself may be in good position, but not unfrequently the first phalanx is flexed (Fig. 182) and the distal one hyper-extended. The condition is probably due to abnormal pressure owing to the valgoid position of the foot, and possibly to wearing too short a boot. It sometimes arises as a result of direct trauma—*e.g.*, a weight falling on the toe, or being 'run over.' **Treatment.**—In the early stages correct the flat-foot, and see that suitable boots are worn. A transverse bar behind the heads of the metatarsals (Fig. 190) is sometimes useful. Careful strapping with Scott's dressing may also give relief. In bad cases where bony changes have occurred (lipping, etc., as in osteo-arthritis), excision of the head of the metatarsal may be required.

Hallux Valgus (Fig. 191) consists of a displacement outwards of the great toe from the median line of the body, as a result of which the other toes are huddled together, and in extreme cases the hallux is placed over or under them. It is present in the majority of people in some measure, owing to the usual shape in which boots are made; but in its severer forms it is due to a chronic arthritis of the metatarso-phalangeal joint, the greater power of the abductor group of muscles explaining the deformity. The cartilaginous surface of the head of the first metatarsal bone becomes inflamed owing to the partial dislocation of the toe and the pressure of the boot; its structure and shape are thereby altered, and the joint is more or less disorganized. Two other conditions are often associated with this deformity—viz., bunion and hammer-toe.

A *bunion* consists in the formation of a bursa over the head of the first metatarsal bone, which becomes inflamed from cold or injury,

and may even suppurate, the abscess often communicating with the joint, and leading to its disorganization. A marked bony outgrowth is usually found under the bursa, springing from the inner side of the head of the bone, and due to a localized periostitis.

The **Treatment** of hallux valgus in its earliest stages consists in the use of correctly-shaped boots, with the inner border straight from toe to heel, whilst the sock or stocking should have a separate compartment for the great toe. The introduction of a toe-post between the great toe and its neighbour is sometimes effective in giving relief. A boot with a cross-bar across the sole (Fig. 190) is also useful by relieving pressure on the heads of the metatarsals. In more severe types excision of the projecting head of the metatarsal bone gives admirable results. The operation is best conducted by turning up a flap of skin and subcutaneous tissues over the inner aspect of the head of the metatarsal with its convexity forwards. The bone is then exposed by splitting the internal lateral ligament and transversely divided by a chisel; the head is removed completely, allowing the toe to be easily replaced in a normal position. The skin is then laid down in place and if need be shortened to meet the requirements of the case. This operation is better than merely removing a wedge from the neck of the bone, or chiselling off the projecting bony overgrowth. The toe should be maintained in a good position by the dressing, and massage is commenced early. A good movable joint results, though the toe is slightly shortened. Care must be taken subsequently to see that suitable boots are worn. Very rarely ought the second toe to be removed for this condition, as the lateral support of the great toe is thus weakened, and the deformity is probably aggravated. An *inflamed bunion* is treated by removing all local pressure, and applying fomentations. If the joint is involved in suppurative disease, excision of the head of the bone, or amputation of the toe, may be required. In less serious cases it may suffice merely to remove the thickened bursa and to chisel away the projecting portion of the bone.

FIG. 191 —HALLUX VALGUS WITH BUNION.

Hammer-Toe.—This deformity is constituted by hyper-extension of the first phalanx, marked flexion to an acute angle of the second, and either flexion or extension of the terminal phalanx, so that the first interphalangeal joint projects under the upper leather of the boot, whilst the patient walks on the extremity of the ungual phalanx, or even on the nail (Fig. 192). Callosities form upon the points of pressure (Fig. 193, 1, 2, and 3), especially on the dorsal aspect, and a subcutaneous bursa over the head of the first phalanx

(4), giving rise to great pain and inconvenience. The second toe is that most frequently affected, with or without the others, but it is uncommon for the hallux to be thus deformed. The extensor tendons often stand out very evidently beneath the skin. The flexion of the second phalanx on the first is often carried to such a degree that the former bone is semi-dislocated. The prolongations of the plantar fascia on either side are much shortened, and the lower portions of the lateral ligaments of these articulations are also contracted.

Causes.—It is occasionally congenital, but more often acquired, and then (*a*) it may be secondary to hallux valgus; (*b*) it may result from wearing short and pointed boots, or very high heels; in either case the toes are crowded together and drawn up out of the way of

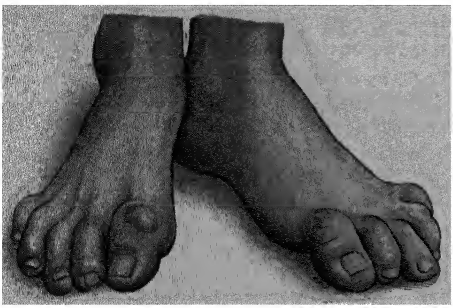


FIG. 192.—HAMMER-TOE DEFORMITY OF ALL TOES OF BOTH FEET WITH MARKED CALLOSITIES OVER THE HEADS OF THE FIRST PHALANGES.

In this case the patient, a girl of seventeen years, was quite crippled Operation was performed on all the toes, the heads of all the first phalanges being removed, and an excellent functional result followed.

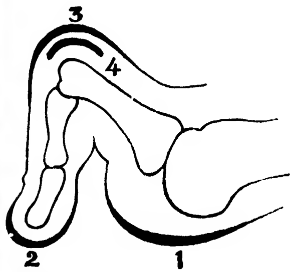


FIG. 193.—HAMMER-TOE. (AFTER KEEN AND WHITE.)

1, Callosity over head of metatarsal bone in sole; 2, callosity over end of toe; 3, callosity or corn over head of first phalanx; 4, adventitious bursa over the same bony point.

pressure; (*c*) it follows contraction of the plantar fascia, and is then associated with pes cavus and talipes equinus.

Treatment may be commenced by the use of correctly-shaped boots, but the case has usually progressed to such an extent when the patient is first seen that no palliative measures are of any avail. Operation is then necessary, and probably the second phalanx is so much displaced that nothing short of removal of the head of the first phalanx holds out any prospect of permanent relief. An incision is made longitudinally over the joint, the extensor tendon being split down the middle; the head of the bone is then cleared by the raspatory, and nipped off by cutting pliers. No splint is required, as the pressure of the dressing suffices to keep the toes in good position. Sometimes there is but little room between the great and third toes, so that even if one corrected the deformity of the

second toe there is no space for it to lie comfortably; amputation should then be performed.

Metatarsalgia, or **Morton's Disease,** is characterized by severe pain of a neuralgic type located primarily about the head of one or more of the metatarsal bones, usually the fourth, but also radiating thence up and down the limb. It often occurs in gouty or rheumatic subjects, and may be attributed to some injury; a slight degree of flat-foot and the wearing of tight boots certainly predispose to it. It is probably due to compression of the digital nerves between the heads of the metatarsal bones and the ground. The foot is found to be broader than usual, and the anterior transverse arch formed by the heads of the metatarsals flattened out. Marked callosities, or corns, are observed on the under surface close to the heads of the bones, one or more of which may be unduly prominent below. In a few cases small bony enlargements have projected from the heads of the metatarsal bones, and in some definite fibrous growths have been found in the subcutaneous tissues; in other cases a simple peripheral neuritis may explain the manifestations. The pain is generally induced by walking, and comes on in characteristic paroxysms. Lateral pressure over the bases of the metatarsal bones often relieves the pain, but similar pressure over the heads usually increases it. Occasionally evidences of osteo-arthritis are manifested in one of the neighbouring joints.

Treatment consists in resting the foot, whilst suitable diet and drugs are ordered to combat any gouty or rheumatic tendency. At the end of a few weeks the patient may be allowed to walk again with boots which are low-heeled, thick-soled, and broad anteriorly with an obliquely set bar behind the heads of the metatarsal bones (Fig. 190). Associated deformities of the foot are dealt with appropriately, and the callosities on the sole by suitable chiropodical methods. Morton's recommendation—viz., excision of the head of the projecting metatarsal bones—may be reserved for the more aggravated and serious forms; it is best effected through a longitudinal dorsal incision running parallel to the extensor tendons.

Painful Heels.—Patients are not unfrequently seen who complain of disabling pain about the heel in spite of careful attention to the fit of boots. This may be the result of not a few various causes, and careful discrimination is necessary to make a correct diagnosis.

1. If the pain is purely plantar, it may be due to a gouty deposit in the deep fascia or muscles, and merely requires constitutional treatment. If, however, this is unlikely, an X-ray examination will sometimes reveal the existence of a bony spur (Fig. 194) from the under side of the os calcis, due to ossification of the attachment of the deep fascia, and resulting probably from strain. Operation in these cases is essential in order to excise the spur and any adventitious bursa that may have formed over it. One need hardly say that the incision should be placed posteriorly (horseshoe-shaped) or laterally, and not in the sole.

2. If the pain is posterior, it is probably due to inflammation of the bursa beneath the tendo Achillis, or to periostitis beneath the insertion of that structure, resulting from strain. If rest is of no avail, igni-puncture may be useful, or the newly-formed bone may even require to be excised.

3. If the pain is deeper and more central, it is possibly due to injury of the bony cancelli in the os calcis, resulting from a fall or

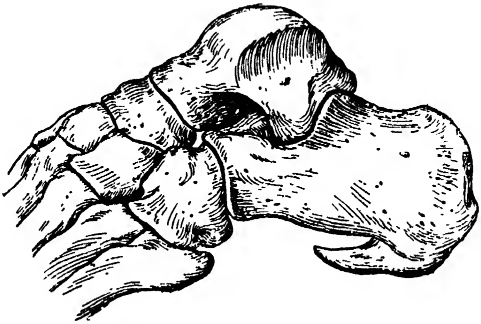


FIG. 194.—BONY SPUR BENEATH OS CALCIS (DRAWN FROM RADIOGRAPH.)

blow on the heel and some secondary osteitis or periostitis. This must be treated on general principles, but it is often very intractable.

The terms ' infantile paralysis ' and ' spastic paralysis ' have been employed so frequently during this chapter as having important ætiological relationships to deformities that it appears desirable to add here a short description of these affections.

Infantile Paralysis.

This condition, by far the most common cause of paralysis in children, is due to an acute infective inflammation of the anterior horns of the spinal cord (*acute anterior poliomyelitis*), resulting in destruction of the multipolar ganglion cells without suppuration, and followed rapidly by paralysis and degeneration of the muscles supplied from that area.

The causative organisms have not yet been actually isolated, inasmuch as they are apparently ultra-microscopic and pass through a filter. Portions of an infected cord inoculated into monkeys produce the disease, and the cell-free fluid obtained after crushing up such cord débris and filtering, even through coarse porcelain, is similarly effective. The virus remains active in a dried cord for some weeks.

Infection apparently commences in the naso-pharynx, and then spreads up the olfactory nerves, causing first a meningeal reaction, and subsequently an invasion of the nervous tissue itself, either of the brain or of the cord, but more frequently of the latter. The

condition of the cerebro-spinal fluid in the acute stage before paralysis has occurred is quite diagnostic: it is under pressure; the albumen content is increased; there is an excess of cells (polymorphs or lymphocytes) with normal sugar and normal chlorides. and no organisms can be cultivated from it; there seems, however, no relation between the number or character of the cells and the type or gravity of the case.

The disease mainly affects children between two and five years of age, but it is not uncommon throughout childhood, and even occurs in adults. The incubation period varies, but in many cases does not exceed three or four days. Infection commences in the naso-pharynx, and hence in schools and other institutions there should be sufficient room in the dormitories to prevent the children from coughing in one another's faces; beds may be arranged alternately head to feet with advantage. The disease is often transmitted by carriers who are themselves immune.

In England anterior poliomyelitis is a notifiable disease, for although it is not usually very common, yet occasionally serious outbreaks occur. It is seen much more frequently in the tropics, and many grave epidemics have been reported in various parts of the world—*e.g.*, the New England states of America and New Zealand. In this country it shows a seasonal variation, three-quarters of the cases developing between June and October.

The **course** of the disease is best described in three stages:

1. The inflammatory **stage of onset** often starts abruptly, and is ushered in by a short febrile attack with severe pain in the head and neck, perhaps extending to the spine; the head is retracted and fixed by muscular spasm, and there is often some hyperæsthesia of the body. This stage may persist for some days and be followed by one of paralysis, or the condition may abort, possibly as the happy result of a spinal puncture for diagnostic purposes. The symptoms are obviously due to the initial meningeal reaction. The paralysis comes on suddenly and rapidly reaches its maximum, within perhaps a few hours, and any change thereafter lies in the direction of improvement. The affected limb is helpless and relaxed, the muscles are completely paralyzed and undergo rapid atrophy; reflexes disappear, as also electric excitability, although the reaction of degeneration may often manifest itself. The affected limbs are cold and bluish in colour. The disease is rarely generalized, but its *distribution* is very variable, mainly involving the limbs, and that in any type of combination. In the arms the deltoid is most commonly affected, less often the biceps, brachialis anticus, and supinator longus; occasionally the extensors of the wrist and fingers are paralyzed. The legs are much more frequently attacked than the arms, and the lower rather than the upper halves; the tibialis anticus and extensors are involved more often than their opponents. In the thigh the quadriceps and adductors bear the brunt of the trouble. The spinal muscles participate in the disease occasionally, but the face and sphincters are not affected.

The inflammatory condition, as indicated by pain and fever, lasts perhaps for six weeks, and is followed by—

2. The **reparative stage,** during which the mischief in the cord is being made good as far as possible by the development of cicatricial tissue, and such ganglion cells as have escaped destruction are beginning to regain their power of control over the muscles dependent on them. This may occur at any time after the passing of the acute stage, and may progress slowly or rapidly, and only after the completion of this period can an assured judgment be formed as to the actual extent of the mischief. A period of two years or more is often occupied in this stage, and during its course deformities are liable to develop, growth is checked, and trophic manifestations may appear. Response to galvanic stimuli is the first indication of repair, and so long as the reaction of degeneration exists, one need never give up hope of improvement; then comes response to faradic excitation, and finally voluntary movement.

3. The **stationary period** is at length reached, when a final opinion may be formed as to the extent of the mischief, and arrangements made for assisting the patient by operative or other treatment, which must not be considered so long as improvement in muscle tonus is occurring. Henceforth, the surgeon's aim is to protect the damaged and weakened limbs from injury, to guide growth along right lines, and to assist impaired function, whilst at the same time provision must be made for the education and amusement of the child with a view to making him ultimately an independent member of the community.

Prognosis, therefore, is most difficult in the earlier stages. No one can tell exactly how much damage has been done in the cord, or how that damage will influence the limbs in the direction of ultimate paralysis or cessation of growth. A prolonged first stage is often a precursor of delayed repair and a protracted recovery. Extensive paralysis does not necessarily connote inefficient growth, which may appear with very slight muscular impairment. Fairly complete early paralysis of both lower extremities usually carries with it a bad outlook, especially if persisting after three months.

Treatment necessarily varies with the stage of the disease, and the practitioner must keep clearly in mind the objects to be attained in each.

In the **first stage** the prime essential is rest and quiet, so that the inflamed and damaged cord may be put in the best condition for checking the destructive process and limiting the mischief caused thereby. The whole body must be immobilized as far as possible in a Thomas's double spinal frame or some such contrivance, and wrapped in cotton-wool to protect it from peripheral stimuli. The feet are placed at right angles to the legs, and maintained thus by splints or plaster applied over thick cotton-wool. The relative position of the thighs to the pelvis must also be watched. Local applications of heat or cold, electricity or massage, are alike harmful in this stage.

In the **second stage** the chief efforts of the practitioner must be directed towards the prevention of deformities, the correction of any that have developed, and the restoration of muscular power and function. Careful study of the case is necessary, in order to determine the electrical condition of individual muscles, which should be carefully charted for future reference.

The *prevention of deformity* is governed by the fact that a paralyzed muscle is always liable to become stretched under the influence of gravity or of opposing muscles, so that even if contractility is in time restored, the over-stretched muscle cannot fulfil its function. All paralyzed muscles must be kept relaxed until recovery occurs, and this applies as much to times when treatment is being undertaken as to periods of rest; massage and electricity must be employed with the affected muscles in a position of relaxation. Splints and postural treatment are also required during this period in order to maintain a correct position. With a paralyzed deltoid, the arm must be kept abducted; for paralysis of the flexors of the forearm, the elbow must be bent to a right angle; for paralytic drop-foot, a position of dorsiflexion must be maintained. All splints during this stage must be light and of a simple nature. As the muscles regain tone and power, a certain limited range of movement is permitted, and gradually increased inch by inch; but the power of the muscle must not be over-taxed, or it will lose rather than gain ground.

The *correction of deformities* is often required owing to neglect in the early stages, and is governed by the principles just enunciated. If muscular re-education and electrical stimulation cannot effect this, appliances to maintain a correct position must be employed, or even operative treatment.

Massage is of the greatest value in the restoration of muscular tone, if applied intelligently. Its object is to stimulate and develop the weakened muscles, and that without undue fatigue. At first gentle friction is alone required, but later the deeper parts can be kneaded. When the time comes for active exercise of the muscles, they must be called into contraction at first without allowing the weight of the limb to exert its influence. *Electrical treatment,* too, must be judicious, or it may be of little value. The immersion of a limb in an electric bath is calculated to exercise the strong rather than the weak muscles, and the retention of the limb in the correct posture under these circumstances is difficult or impossible. Interrupted galvanic stimulation to the individual muscles is the best form to employ until sufficient repair has occurred to permit of response to faradic stimuli, and then this variety may be utilized. Over-fatigue of the muscles must not be permitted.

In the third or **chronic stage** the surgeon's chief object is to restore the patient's usefulness, so far as is possible, by correcting deformities and stabilizing weak and flail-like limbs. *Mechanical appliances* are often needed, but must be carefully devised in order to assist, and not to hamper movement by unnecessary weight.

Celluloid, papier-maché, or some such material may be utilized for the simpler cases, whilst for metal contrivances duralumin may sometimes take the place of steel. In paralytic talipes equinus irons fixed to the boots and rising above the knees, or even sometimes running up to the pelvis, are frequently required.

Operative measures are directed towards either the restoration of the muscular balance or to the fixation of a flail joint. (*a*) Division of tendons or fasciæ is seldom desirable in paralytic cases; the muscles of the limbs are already sufficiently weakened. However, in paralytic drop-foot, contraction of a healthy tendo Achillis is sometimes so great that the foot cannot be restored to its correct position by passive movement, and then it must be lengthened; shortening of over-stretched paralyzed muscles is seldom of much use. (*b*) *Tenoplasty* (p. 469), or the grafting the tendon of a healthy muscle into a paralyzed one, has a certain limited scope in this affection, but requires the most precise recognition of the value and utility of the muscles employed. (*c*) *Tendon-fixation* (p. 470) is of some value as a means of stabilizing a flail limb—*e.g.*, in paralytic drop-foot—but unless the tendons are fixed very near to the articular surfaces, and only short lengths employed as accessory ligaments, they are extremely likely to stretch subsequently. (*d*) *Arthrodesis*, or the fixation of joints, is a useful proceeding when the unnatural mobility is difficult to control, or would necessitate considerable addition to the weight of any apparatus required, or where from the poverty of the patient such apparatus cannot be obtained. It is especially serviceable in cases where two joints in a limb are flail-like, one of which may be ankylosed with advantage. The operation consists in a modified excision, the cartilage alone being sawn or scraped from the ends of the bones, but it must always be remembered that the reparative activity in a paralyzed limb is small. It is usually unnecessary in the hip-joint; it is decidedly valuable for the flail knees of older children, where the expense of apparatus has to be considered. A stiff ankle is undesirable, but arthrodesis of the astragalo-calcanean joint is useful if suitable tendon operations can be arranged to steady the ankle. (*e*) Where the whole limb is hopelessly powerless and an inconvenience to the patient, *amputation* is often the best practice. In the lower extremity, when the knee and ankle are both weak and flail-like, arthrodesis of the knee and removal of the foot by a Syme's amputation will often provide the patient with a serviceable limb.

Spastic Paralysis (*Syn.:* Little's Disease, Cerebral Diplegia, etc.).

Under this title are included a group of cases in which the characteristic feature is spasm of various groups of muscles, leading in time to a fixed deformity, and weakness or paralysis of other muscles, possibly the opponents of the above. The cause is always some permanent defect of the upper motor neurons, which not only

impairs the passage of excito-motor impulses, but also hampers the conduction of inhibitory impulses from cortex to spinal centre. The result of this is that peripheral stimuli reaching the centres from below have an undue power of producing reflex activity, and hence, in such conditions as the cerebral diplegia of children, spastic contraction of muscles is induced, and the mere placing of the foot on the ground in the attempt to walk produces such spastic contortions as to render progress difficult, if not impossible.

A certain degree of spasticity occurs in various diseases of the central nervous system in *adults*—*e.g.*, after hemiplegia (but preceded in this case by a period of flaccid paralysis), in disseminated sclerosis, etc.; but it is not necessary to discuss these.

In *children* spastic paralysis may be due to localized polio-encephalitis, cortical thrombosis (post-exanthematous), or syphilitic disease; but in the great majority of cases it is a birth palsy, probably resulting from punctiform hæmorrhages in the cortex or pons, occurring during birth from undue moulding of the bones of skull or from asphyxia, and this in spite of the story of a normal labour, which is usually forthcoming.

The affection may appear as a hemiplegia, diplegia, paraplegia, or monoplegia, the two former being the more common and occurring in the proportion of 9:7. The characteristic contractures are as follows:

In the lower extremity, spastic equinus, due to inefficiently controlled plantar-flexion of the foot; flexion of the knee and adduction of the thigh, combined sometimes with internal rotation.

In the upper extremity, pronation of the forearm and flexion of the wrist.

(*a*) At first the contractions can be overcome and the limb straightened, although the mere attempt to do so often induces spasmodic action of the muscles, which, however, can be banished by deep anæsthesia. In time the contracted muscles become actually shortened, and restoration to the normal position is impossible. (*b*) The actual loss of muscular power in the opposing group varies much in degree, but is always present, and must be taken into account in considering operative treatment; this applies particularly to the arm lesions. (*c*) Mental deficiency to a greater or less degree is commonly present in these patients; in hemiplegia 68 per cent. are subnormal, and in cerebral diplegia 84 per cent. The mentality of every patient should be carefully considered before undertaking a course of treatment which requires the co-operation of the patient for its successful completion. (*d*) Involuntary movements of an athetotic type are often evident in these cases, and will seriously hamper all attempts at treatment.

Treatment.—Massage and electricity to the muscles, however devotedly applied, are useless in effecting a cure, and can never be of much use; operative treatment can alone be expected to be of any lasting benefit.

Stoffel's operation consists in division of a sufficient number

of the motor fibres leading to the spasmodic muscles to restore the balance of control, and to render them more on a level with the weakened group of opposing muscles. This theory has been substantiated in practice to a great extent. Spasmodic equinus is dealt with by dividing a half or two-thirds of the nerve tracts to the gastrocnemius and soleus, but this must sometimes be accompanied by local treatment to lengthen the tendo Achillis. Flexion contracture of the knee requires division of a sufficiency of the nerve-fibres leading to the hamstring muscles, but older cases also need tenotomy of these muscles. Adductor spasm is treated by division of branches of the obturator nerve. For pronation and flexion of the forearm and wrist, the nerves to the pronators and flexors may be attacked, but the results are not very favourable, owing to the degree of weakness usually present in the opposing groups; it may be wiser in such cases to employ these muscles by transplanting them so as to strengthen the weak supinators and extensors of the wrist and fingers, in the same way as they are used in old musculo-spiral paralysis (p. 432).

The actual method of division of the nerve-fibres varies somewhat; Stoffel's original suggestion was to deal with the main trunks, depending upon the knowledge now available as to the arrangement of the fibres in these trunks; other surgeons divide the peripheral nerves close to the muscles, although this involves a much more extensive dissection.

Re-educational exercises must be instituted as soon after the operation as is considered safe, and here the question of the patient's mentality arises. Considering the unpromising material on which the work has to be done, the results have been most encouraging, but it is obvious that unless the patients are brought under observation early, the prognosis is likely to be unfavourable.

CHAPTER XX.

INJURIES OF BONES—FRACTURES.

Contusion of a Bone and of its periosteum is usually a matter of no great moment, although the part becomes painful and swollen. Occasionally a subacute periostitis is caused in people liable to rheumatism or gout, or in the subjects of syphilis; whilst in those with low germicidal power acute infective osteomyelitis, resulting in necrosis, may supervene. If the periosteum is torn, osteogenetic cells may be set free from its under-surface and escape into overlying muscles, leading to new bone-formation therein (traumatic myositis ossificans, p. 463). **Treatment** consists in rest and the use of cooling lotions or of a bandage, whilst if periosteal thickening results, iodide of potassium may be given, and iodine paint applied locally.

Bending of Bone may or may not be associated with fracture. Bending without fracture occurs mainly in children, and in adults is only the result of some local disease. More commonly a partial or green-stick fracture is produced (p. 531), and in this the deformity can generally be corrected without much difficulty.

Fractures.

A fracture may be defined as a sudden solution of continuity in a bone, usually resulting from external violence.

Predisposing Causes of Fracture—*Age.*—From two to four fractures are not uncommon, owing to the unsteady gait and frequent falls to which little children are liable; from four to six the bones often bend so as to cause green-stick fractures; up to the age of eighteen years injuries near joints induce separation of epiphyses; from six years onwards fractures increase in frequency, reaching their maximum between thirty and forty years of age; old people are liable to this form of accident, owing to the bones becoming atrophic or brittle.

Sex.—As might be expected, fractures are more common in the male sex during boyhood and adult life; but up to the age of four or five they are equally frequent in the two sexes, whilst after forty-five they are more common in women, owing to their great liability to fracture of the cervix femoris and to Colles's fracture.

Morbid Conditions of the Bones predispose in a marked manner to what is known as *Spontaneous Fracture,* in which the determining

force cannot be recognized or is very slight. Under this heading may be included: (1) Atrophy of bone, which may be of the senile type, as manifested especially in the cervix femoris; or is due to want of use, as in a paralyzed limb or from an ankylosed joint. (2) Patients afflicted with certain mental or nervous diseases, such as general paralysis or tabes dorsalis, are unduly liable to fracture, which may occur in apparently healthy bones. A man, for instance, suffering from tabes was sitting with his thigh abducted and everted in order that he might examine and dress a perforating ulcer on the sole of the foot, when the shaft of the femur, subsequently shown to be of normal dimensions, and apparently of normal density, snapped in two. (3) Osteogenesis imperfecta (p. 666) consists in an inherited tendency to spontaneous fracture. Thus, a girl, aged twelve and a half years, had suffered from forty-one fractures since the second year of life. (4) General bone diseases, such as rickets and osteomalacia, also predispose to fracture; in the latter affection the bones often bend considerably before breaking. (5) Local bone disease, such as sarcoma and secondary cancer, may also be first recognized by causing a spontaneous fracture; the erosion of an aneurism and the destruction of the para-epiphyseal region in acute osteomyelitis may lead to a similar result.

The **Exciting Causes of Fracture** are threefold: (1) *Direct violence*, the fracture occurring at the spot struck, and being often transverse, not unfrequently comminuted, and sometimes complicated with injuries to the adjacent soft parts. (2) When due to *indirect violence*, the accident is usually produced by the compression or bending of the bone with such force as to exceed the limits of its natural elasticity, so that it yields at the weakest spot. Thus, when a person jumps from a height, the leg bones are compressed between the weight of the body and the resistance of the ground, and, if the violence is excessive, a fracture occurs at some point of mechanical disadvantage. If the stress falls chiefly on the shaft, an oblique fracture ensues, often with much longitudinal displacement, and possibly becoming compound; if an element of torsion is present, as by forced inversion or eversion of the foot, the fracture is likely to become spiral in type. If, on the other hand, the violence expends itself on a mass of cancellous tissue, such as the os calcis, astragalus, or upper end of the tibia, the bone may be fissured in various directions, comminuted, or even 'pulped'; such a condition is sometimes termed a *compression fracture*. (3) *Muscular action* is most commonly the cause of fracture of small bones or of osseous prominences, into which powerful muscles are inserted. The patella and olecranon are not unfrequently broken in this way, the former often occurring from sudden and vigorous efforts to avert a fall. Occasionally one of the long bones, such as the humerus or clavicle, has been broken by violent muscular exertion, as by throwing a cricket-ball.

Intra-uterine Fractures are caused by blows upon the mother's abdomen, or by abnormal or violent uterine contractions, especially

if the liquor amnii is deficient in amount or if the formation of bone is defective, as in osteogenesis imperfecta (p. 666); they are usually followed by considerable deformity. **Obstetric Fractures** occur during delivery, usually affecting the shaft of the femur or humerus.

Varieties.—A **Closed (Simple) Fracture** is one in which the skin is unbroken, or, at any rate, where the external air has no admission to the site of injury. An **Open (Compound) Fracture** is present when the skin or mucous membrane is so lacerated that there is direct or indirect communication between the fracture and the external air. In the base of the skull, a fracture may involve one of the deeper air-sinuses, and thus becomes compound without any apparent external lesion.

Fractures are complete or incomplete, according to whether or not the continuity of the bone is entirely interrupted. Various forms of **Incomplete Fracture** are described, and indeed the introduction of

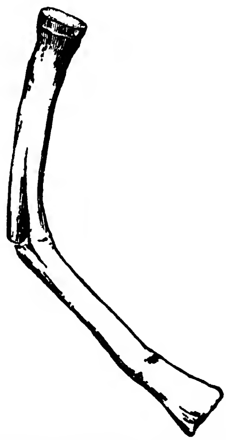


FIG. 195.—GREEN-STICK FRACTURE OF RADIUS.

radiography has shown that they are much more common than was formerly supposed. A *green-stick fracture* (Fig. 195) (R.S., Fig. 4) is one which only occurs in young children, and most often in those that are rickety; curved bones, such as the clavicle, are most frequently affected, and the fracture merely involves the convexity of the curve, whilst the concave half is bent, just as when a green bough or twig is partially broken. *Depressions* of the skull may be similarly incomplete when the outer table is driven in without fracture and the inner table alone splintered. *Fissured fractures* also are often only partial. A *subperiosteal fracture* is one in which the periosteum remains intact, although the bone is broken; displacement does not occur, and therefore the injury is likely to be overlooked, apart from radiography.

Complete Fractures may be *transverse*, if due to direct violence; *oblique*, arising usually from indirect violence; *spiral*, when the

force acts in a rotary direction as well as longitudinally; it occurs most frequently in the tibia or femur, and the lower fragment often has a sharp triangular upper end, giving it somewhat the appearance of the mouthpiece of a clarionet (fracture *en bec de flute*). Not uncommonly a second fissure runs downwards from the main line of fracture, separating off a long narrow fragment of the shaft. A *longitudinal* fracture is one due to fissuring or splitting of the bone in its long axis; it is most common as the result of gun-shot injuries. If it is combined with a transverse fissure, it is often termed T-shaped. *Comminuted* is a term used to describe the condition when the bone is broken into more than two pieces; *impacted*, when one fragment is driven into the other; *multiple*, when more than one fracture exists; *complicated*, when important structures, such as an artery, nerve, or joint, are damaged as well as the bone.

The **Separation of an Epiphysis** results in young people from violence directed to the ends of the bones, but occasionally from pathological affections of the epiphysis or of the adjacent portion of the diaphysis—*e.g.*, from inherited syphilis, rickets, scurvy, acute osteomyelitis, or tuberculous disease. The femur, humerus, or radius are the bones most often affected. The line of cleavage usually runs through the soft spongy tissue on the diaphyseal side of the cartilage, so that there is cartilage with spicules of bone on one side and spongy bone on the other. In very young children, where the epiphysis is entirely or mainly cartilaginous, the lesion is almost always a pure separation of the epiphysis from the shaft; but at a later date it not unusually extends in part through the adjacent end of the diaphysis (Fig. 226). A marked feature is the stripping up of the periosteum, which, though loosely attached to the shaft and easily separated from it in children, is firmly adherent to the epiphyseal cartilage, and hence retains its connection with it, thus frequently limiting displacement. If, however, the force is sufficient, the end of the shaft penetrates the periosteum, which grasps it closely, and this periosteal 'sleeve' often hinders reduction. Union usually occurs by means of bone, but arrest of the longitudinal growth may follow if the parts are not replaced in exact apposition. This is a matter of importance when one of the bones of the leg or forearm is affected, since deformity of the hand or foot results if the injured bone ceases to grow and the uninjured one continues its development. Suppuration sometimes follows in unhealthy children, or when the accident is compound, and may result in acute osteomyelitis.

Partial detachment of an epiphysis (the *juxta-epiphyseal strain* of Ollier) often occurs, giving rise to phenomena similar to those of a sprain; it may determine an attack of osteomyelitis, and, if neglected, may lead to tuberculous disease, or may interfere with the growth of the limb. The essential feature is a more or less tender, but very distinct, swelling of the bone close to the epiphysis, but the neighbouring joint remains unaffected. Treatment consists in immobilization in plaster of Paris.

Signs of Fracture.—The history usually given by the patient is that, as the result of some accident, he felt, or perhaps heard, something give way with a snap, and experienced sharp pain which became much intensified on attempting to move the limb. On examining the injured part and contrasting it with the opposite side, the following points are usually noticed:

1. The *signs of a local trauma,* viz., pain, bruising, and swelling, as a result of the effusion of blood from the torn and lacerated structures. The amount of this may be so great as to obliterate all the ordinary bony prominences and landmarks. Blebs and bullæ sometimes appear over the surface after a day or two, and must be carefully protected from infection. The discoloration may spread by gravity to parts far removed from the original mischief. This infiltration often leads to considerable subsequent thickening, and possibly to adhesions and limitation of movement. It is unusual for suppuration to occur after a closed fracture, unless the patient is very debilitated and with diminished germicidal powers.

2. *Preternatural mobility in the continuity of the bone* may be demonstrated by manipulation, but never unnecessarily. Impaction or non-separation of the fragments prevents its occurrence.

3. Partial or complete *loss of function* also follows.

4. *Crepitus** can only be felt when the fragments are moveable and can be brought into contact, but not when there is wide separation, complete overlapping, or impaction.

5. Change in shape of the limb or *deformity from displacement* results from three chief factors, viz., the direction of the violence, the weight of the limb, and the contraction of muscles, whilst injudicious movement or rough handling may aggravate it. It is always more marked in oblique than in transverse fractures, and hence is usually greater in those due to indirect violence. Various types of displacement are described, viz.: *Angular,* generally due to the unequal action of powerful muscles; *lateral,* where the displacement is merely to one or the other side, and most common in transverse fractures; *longitudinal,* when one fragment overlaps the other or is forcibly driven into it, causing shortening of the limb; it may also occur in the form of wide separation of the fragments, as from contraction of the quadriceps in fracture of the patella; *rotatory,* when one fragment is twisted on the other, as in fractures of the femur, where the weight of the limb causes eversion of the lower end. In flat bones—*e.g.,* the skull—deformity may exist in the shape of *depression* or *elevation.*

* The term *Crepitus* is applied to five different conditions which may produce a creaking or grating sensation to the examining hand. 1. *Bony* crepitus results from the rubbing together of the fragments in a fracture, or of the ends of bones in a joint when denuded of their articular cartilage. 2. A softer variety of bony crepitus is obtained when an *epiphysis* is detached. 3. An effusion of *blood* into the tissues gives rise to a soft crackling sensation on handling. 4. *Effusion* into tendon sheaths, bursæ, and joints also causes a soft crepitant sensation, varying in different cases. 5. *Air* in the tissues causes surgical emphysema and a characteristic form of crepitus.

Radiography has proved of the greatest service in connection with both the diagnosis and the treatment of fractures. Many a case which would formerly have been called merely a sprain can now be demonstrated to be really a fracture (especially about the wrist and ankle), and its constant use has revolutionized our ideas as to the relative frequency and nature of many such lesions. Indeed, there is at the present time too great a tendency to rely on radiography for diagnosis, to the detriment or loss of that delicate tactile sensation which surgeons of old days had to acquire. The diagnosis of most fractures *can* be made without the use of radiography; its employment should be looked on as confirmatory, and only diagnostic in difficult cases. It is most important, however, that the result of 'putting up' the fracture should be tested by radiography, as thereby defects of alinement may be recognized and early corrected.

A satisfactory diagnosis can never be made with the screen alone; the limb must be photographed, and for choice stereoscopically; otherwise, the skiagram should be taken in two directions. The importance of this is indicated by a study of R.S., Figs. 10 and 11. It must also be remembered that all skiagrams are more or less exaggerations, varying with the proximity of the tube to the limb, and thus a deformity which is very obvious in the radiograph may in reality be comparatively slight. Finally, one must not forget that callus is for a considerable time pervious to the X rays, so that, although the fracture is firmly united, it may be still apparent in the skiagram.

General or Constitutional Effects.—*Shock* is greater or less according to the character of the violence, the seat of injury, and the amount of pain caused by the accident and its treatment.

Hæmorrhage is rarely sufficient to give rise to general effects unless the fracture is open, and involves some important vessel.

Fracture fever (aseptic traumatic fever) is met with in the majority of cases, commencing twenty-four hours after the accident and lasting two or three days. As a rule, it is not severe, the temperature rarely rising above 100° F. in uncomplicated cases. In open fractures where asepsis has not been attained, any variety of wound infection may result, and even general septicæmia or pyæmia.

Delirium tremens is a not unusual complication of fractures of the leg in debilitated individuals or habitual drinkers. The general characters and treatment of the disease are dealt with elsewhere (p. 285). As regards local treatment, the limb must be fixed by splints or encased in plaster of Paris, and suspended so as to prevent the patient from moving the upper fragment independently of the lower.

Fat embolism results from the absorption of broken-up fat globules after any injury which causes contusion or laceration of fatty tissue; when this is accompanied by tension from effusion of blood, as in fractures, this process is more likely to occur. Usually the greater part of the fat absorbed is filtered off by the lungs or eliminated by

the kidneys (as can be demonstrated after death by staining with osmic acid), and no harm results. The pulmonary obstruction may, however, become so great as to lead to a fatal issue from dyspnœa; whilst if the cerebral vessels are blocked, syncope, or even coma, may be induced. The symptoms are gradual in their onset, and usually commence about the third day, but may not be evident for a week. It is a rare complication.

Union of Fractures.—The broken ends of the bone are left rough, spiculated, and more or less separated one from the other; the periosteum is torn, but the rupture is not always complete, a 'periosteal bridge' covered with osteoblasts perhaps persisting and playing an important part in the reparative process, especially if correct alinement is not obtained. The muscles and neighbouring tissues are lacerated, and a varying amount of blood is extravasated, occupying the interstices of the wound. In the course of a few hours after the parts have been immobilized, the process of repair is inaugurated by the blood-clot becoming invaded by leucocytes, and after a time it is absorbed, the hæmoglobin passing through various stages of degeneration, and thereby staining the surrounding tissues. At the same time all the injured and lacerated soft parts around become hyperæmic, and the connective tissue cells therein proliferate actively. The periosteum becomes thickened and more vascular, and its connection with the bone is loosened for a short distance on each side of the fracture. Thus the whole area of the lesion, limited more or less by the torn and loosened periosteum, is converted into a cellular mass, in which a gradually diminishing amount of blood-clot is present. This is vascularized from the tissues around, and after passing through a stage practically identical with the granulation tissue of the soft parts is converted into soft vascular bone, known as *callus*. The ossification of the vascular and cellular exudate is always determined by the activity of osteoblastic cells, derived either from the exposed and damaged bony tissue or from those always present on the under surface of the periosteum. Wherever these travel, they retain their bone-forming potentialities, and hence the ossification of the cellular exudate is rapid, as it can be carried on from many foci.

1. On the outer aspect of the fragments beneath the torn and stripped-up periosteum the amount of the cellular exudate depends on the fixation or otherwise of the fragments, and on their vascularity. The underlying bone surface becomes more vascular than usual and less dense, the entrances to the Haversian canals being enlarged. Ossification is quite early in starting, and spreads from the bone towards the periosteum. It is upon the ossification of this external or *ensheathing callus* (Fig. 196, A) that the loss of discontinuity of the two fragments depends in the early stages. When a periosteal bridge has been left between the fragments, bone formation commences on its under surface, because of the continued activity of the osteoblasts stripped off with it; in skiagrams a line of newly-formed bone cannot unfrequently be seen passing from one

fragment to another, especially on the concave side, if there is still some degree of angulation, and evidently due to this cause.

2. Similarly changes occur in the medullary cavity—at first, hæmorrhage; then absorption of the blood-clot, and its replacement by a cellular exudate; then a certain degree of absorption of the bony walls, which become more vascular than previously; and finally from the bone ossification starts in the cellular exudate, which becomes thus transformed into a plug of soft bone, extending up and down the medullary cavity for a varying distance on each side, and perhaps, if apposition of the fragments is not perfect, becoming continuous with the external callus. This is known as the *internal callus* or *medullary plug* (B), and assists in maintaining the continuity of the limb during the earlier stages of the process of repair.

3. Naturally the compact bony tissue is the last to engage in these changes, and the denser the bone, the longer they are in being completed. The fractured ends become hyperæmic, the Haversian

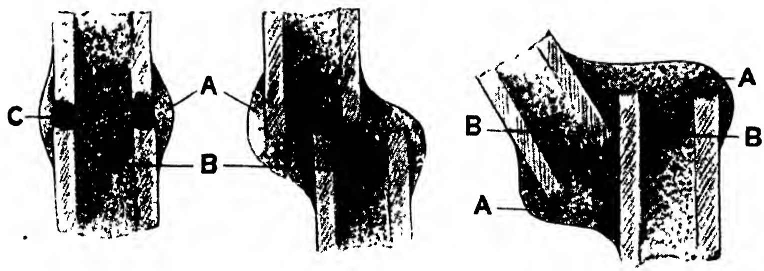


FIG. 196. FIG. 197 FIG 198.

DIAGRAMS TO REPRESENT UNION OF FRACTURES: FIG. 196, WHEN THE ENDS ARE IN CLOSE APPOSITION; FIG. 197, WHEN THE ENDS ARE ONLY PARTIALLY APPOSED; AND FIG. 198, WHEN THE FRACTURED SURFACES ARE NOT IN CONTACT AT ALL.

A, External or ensheathing callus, B, medullary plug or internal callus; C, definite or permanent callus

canals are dilated by absorption of their lining walls, and the bone cells proliferate, so that on section the bone assumes a more spongy texture than usual. In time it becomes converted into a tissue which is practically identical, and becomes continuous, with that of the internal and external callus. Thus is developed the annular bond of union between the two layers of compact bone which used to be termed the *definitive* or *permanent callus* (C).

It will be obvious that the continuity of a bone is restored long before repair is completed, and that it mainly depends on the ossification of the ensheathing callus, the amount of which is to some extent proportional to the degree of mobility of the fragments. A certain formation of cartilage often occurs in the process of bone-repair, especially in young people, and where there is much mobility; it is present chiefly in the early stages, and mainly in the ensheathing

callus. The newly formed osseous tissue is at first soft and spongy, but gradually becomes denser; at first it is easily detachable from the underlying bone, but later on is continuous with it. As the so-called definitive callus increases in strength, the ensheathing callus is absorbed, and finally, if the ends are in good position, may vanish entirely, whilst the medullary plug may also be totally removed. Thus it is possible for the bone, under these circumstances, to be restored so absolutely as to show no signs of its having been fractured.

When the ends of the bones partially overlap (Fig. 197), the amount of ensheathing callus is considerably increased, and fills up all the spaces left by the overlapping of the fragments. The projecting edges of bone become rounded off, and the medullary cavities closed by plates or plugs. The main bond of union is the ensheathing mass, a considerable portion of which persists. Some deformity is certain to remain, and it is unusual for the medullary canal to be restored.

If the fractured ends overlap completely, but remain in contact (Fig. 198), the union is secured by a large mass of ensheathing callus (A), whilst the medullary cavity of each fragment is closed by a plate of internal callus (B).

If the fractured ends overlap and are kept from contact by the interposition of muscular tissue, union rarely takes place, and an ununited fracture results. The same occurs if the fragments are widely separated, as in the patella. In these cases but little change takes place in the bone at first beyond the closure of the medullary canal or of exposed cancellous spaces by granulation and then by fibrous tissue; at a later date the bone ends are likely to undergo a certain degree of atrophy dependent on the amount of disability.

Where *comminution* has occurred, the splintered fragments are matted together by an abundant cellular exudate, which is subsequently transformed into callus. Each of the fragments may become a centre of ossification, and it is astonishing in some of these cases to note the rapidity with which extensive shattering is made good in the absence of infection or great displacement. Sometimes, however, fragments of *compact* tissue may remain for a long time unchanged and with no sign of repair, and may even constitute a cause of non-union by being wedged between two fragments, thus keeping them apart.

The removal of the clot and the formation of the cellular exudate usually takes about a week or ten days, and new bone formation commences about the end of the first week. By the second or third week, according to the size and vascularity of the bone and the recuperative power of the individual, the fracture will be consolidated, but, of course, cannot bear any serious strain. In the leg it is often eight or ten weeks before the patient can bear any weight upon it, and three to six months must usually elapse before a patient should be allowed to walk on a fractured thigh.

The soft tissues around—muscles, tendons, etc.—are repaired in the usual way, but owing to their laceration and infiltration with blood the muscles may become the seat of marked fibrous changes interfering with their contractile power, or may be fixed more or less

firmly to the bony surface over which they ought to play smoothly, or may be matted together and lose to some extent their power of independent movement. Tendons often become adherent to their sheaths, or may be embedded in a mass of cicatricial tissue, and hence the mobility of distal parts may be impaired in spite of the union of a fracture in good position. Neighbouring joints may become stiff as a result of periarticular infiltration, resulting in contraction of ligaments. Nerves and vessels may be torn by the displacement of the fragments, or compressed in cicatricial tissue or callus—and hence the functional result of the union of the fracture may be very disappointing.

In conclusion, one may allude to the fact that a sarcoma sometimes develops at the site of fracture within a comparatively short time of the accident. It is always, however, a question whether the sarcoma was not existent beforehand, and the determining cause of the fracture.

First Aid.—In moving the patient from the spot where the accident happened, it is necessary to secure the limb temporarily in as good a position as possible; splints have often to be improvised from sticks, umbrellas, newspapers, and so forth. In a railway accident the splintered débris of the carriages may be employed for this purpose, and the upholstery of the seats as padding. A broken leg may also be firmly tied to the other limb, which is thus converted into a temporary splint.

The **Treatment** of simple fractures resolves itself into three desiderata—viz., (1) The remedying of the deformity due to the solution of continuity in the bone, and its restoration to a true alinement—*i.e.*, accurate 'setting' of the fracture, as it used to be termed; (2) the fixation of the limb in such a manner as to permit the fragments to unite with a minimum of deformity; and (3) the maintenance and restoration of the function of the limb.

I. The **reduction of the deformity** and the restoration of the bone to correct alinement require a careful study of each lesion and the effect produced on the position of the fragments by the muscles of the part. The deformity, as already stated, is due to three main factors—viz., the causative violence, the action of gravity, and the pull of muscles. The chief methods employed to overcome these are extension of the limb by traction, relaxation of the affected muscles by position, and careful manipulation to place the fragments in apposition; the effect of gravity is overcome by supporting the limb. Not unfrequently it is possible by flexion of a neighbouring joint to relax all muscular tension, and the fragments then fall into position almost without manipulation; in more troublesome cases, longitudinal traction upon the distal end of a limb with the joint above the fracture fully flexed will permit of suitable coaptation of the fragments. One cannot insist on this too strongly in reference to fractures below the knee; flexion of the knee relaxes the gastrocnemius and therewith the tendo Achillis, and it is often easy to reduce a fracture with a bent knee when traction with the limb straight has completely failed. Care must also be taken to ensure

that no abnormal rotation is present, and to this end the sound limb must be uncovered for purposes of comparison.

As the manipulation is always painful and may elicit muscular spasm, it is often necessary to administer an anæsthetic, and it may be wise to make the attempt with the assistance of the radiographic screen. No undue delay should occur in undertaking the putting-up of a fracture, as stiffness and infiltration soon follow and make the operation more difficult, but it is always desirable to delay it for a few hours so as not to administer an anæsthetic with the stomach full.

The recognition for the need of **Prolonged Extension** in the treatment of certain fractures of the shafts of the long bones makes it necessary to draw special attention to the principles underlying this procedure, and the means available for securing their correct application.

1. *Sufficient force must be employed to counteract muscular contraction and spasm,* which are the chief elements in maintaining the deformity. Formerly the application of a weight of 7 to 10 lbs. under unsuitable conditions was usually thought to be ample for a fractured femur; but the results obtained were certainly not satisfactory. In the thigh of a muscular adult a weight of from 10 to 20 lbs, acting ~~freely is~~ probably by no means too much.

2. Since the object of the extension is to stretch the muscles which control the fragments, it is most important to secure a *sufficient grasp* of these structures. The femur, for example, is surrounded by muscles, all of which, whether extensors, flexors, or adductors, are assisting in pulling up the lower fragment. The whole muscular envelope needs to be stretched, and if this is effectively performed, the bone ends are much more likely to become satisfactorily approximated. It is insufficient, therefore, to apply the adhesive plaster merely up to the line of fracture; the whole muscular envelope up to the next joint should be included.

3. At the same time *joints must be left free* to allow of mobilization at an early date. For the femur, the adhesive plaster may be prevented from touching the skin over the projecting femoral condyles by bandaging over them a piece of gauze or lint; for fractures of the leg bones, the projecting malleoli must be protected.

4. It is essential that *the limb should be slung clear* of the bed, so that the traction may exercise its full power without frictional resistance. Long rigid splints, such as Liston's or Macintyre's, must also be excluded from the dressing if the extension is to be effective. Short splints guarding the fragments of the bone and helping to keep them in position may be of use, but must not extend beyond the neighbouring joints. Skeleton splints of the Thomas or Hodgen type avoid these difficulties.

5. Effective *counter-extension* must always be provided, and in the lower extremity the weight of the body is effective in this direction if the lower end of the bed is sufficiently raised; with the heavier weights now employed, the bed-end must be raised more than was formerly the custom.

6. It is essential to *control treatment* of certain fractures—*e.g.*, oblique ones of the femur or humerus—*by radiography* of the limb at intervals during the treatment to make certain that no slipping of the fragments has occurred, and this is most important during the early stages, as it is easy to correct mistakes whilst the union is still plastic.*

In cases where, in spite of suitable extension combined with relaxation of muscles and manipulation, it has been impossible to secure or maintain coaptation of the fragments, operative measures will have to be considered (p. 543).

7. The importance of securing union with correct alinement of the fragments cannot be exaggerated, for although one cannot promise without doubt that perfect function will be recovered, and although all surgeons can produce cases where good function is associated with defective alinement, yet statistics prove incontestably that good functional results are much more likely to occur if the restoration of the bone is as nearly perfect as possible. Thus the Fracture Committee of the British Medical Association,† reported as follows:

Good anatomical result, 1,736 cases. Good functional result, 1,576 cases (90·7 per cent.).

Moderate or bad anatomical result, 1,279 cases. Good functional result, 380 cases (29·7 per cent.).

II. The **fixation** of a fractured limb, so as to permit of suitable repair of the bone, involves (A) the application of splints and similar contrivances in order to keep the approximated fragments in correct position and alinement, or (B) the adoption of operative treatment.

A. **Splints** may be made of wood, leather, poroplastic, etc., according to the requisites of the case. If of wood or metal, they are usually made according to some general pattern, and fitted to the patient by means of pads. If formed of leather, papier-mâché, or poroplastic, they can be shaped so as to meet any peculiarities of the part, softened by immersion in hot or cold water, moulded to the limb, and allowed to dry. Where leather is employed, the addition of a little vinegar to the water assists in rendering it soft and supple. The edges and corners are finally rounded, and the interior padded with wool or lint. Splints must be sufficiently large to encase the part firmly, or if flat, to project a little beyond it, so that the limb may be fixed by the splint, and not the splint by the limb. In all cases careful attention must be given to the padding, so as to prevent irritation of or undue pressure on the skin, which may result in splint sores (p. 126). In out-patient practice, where patients are not too careful as to personal cleanliness, it is advisable to pad the splint with some antiseptic material, such as boracic lint, in order to prevent the development of vermin, but in all cases it is wise to shave and purify the limb, and to dust it over with boric acid and starch. When blebs or blisters have developed,

* Where many fractures are likely to be treated, a portable X-ray machine is essential, and hospital authorities must be urged to provide this in spite of its cost; in the long run, it will prove to be an economy.

† *Brit. Med. Journ.*, 1912, vol. ii., p. 1523.

a dry aseptic dressing should first be applied. The splints may often with advantage be fixed to the limb by one or two strips of adhesive plaster, and then secured by ordinary calico bandages; these must not be applied too tightly, since the limb not unfrequently swells after the accident, and undue constriction resulting in gangrene might ensue. Moreover, a limb ensheathed in bandage must never be flexed, but the flexion should always be made beforehand; otherwise the bandage may cut into the soft tissues, and by compression of the vessels cause gangrene. The condition of the fingers or toes is a sufficient test as to the activity or not of the circulation.

In all cases where prolonged extension of the limb has to be maintained, the employment of the form of splint described above is not satisfactory, and *skeleton splints* of the type devised by Hodgen (Fig. 243) or Thomas are now generally used, suitably modified for arm and leg. The essential element of Thomas's splint (Fig. 199) is

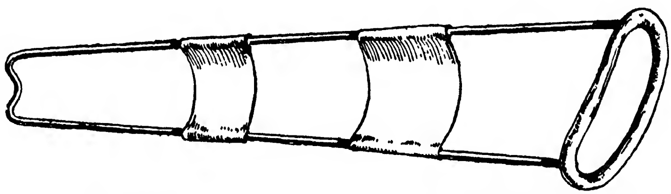


FIG. 199.—THOMAS'S SPLINT AS EMPLOYED FOR FRACTURE OF THE LEG.

a well-padded ring above, through which the limb is passed; it is pressed home either against the chest wall and axilla, or against the tuber ischii. The skin against which it rests must be shifted from time to time and well protected, so as to prevent the development of splint sores. On either side a straight or bent iron bar passes down, attached above to the ring, and terminating below in a cross-piece, the level of which is well below the sole of the foot or tips of the fingers. Extension arrangements are fixed to the limb by glue or adhesive plaster, and attached to the cross-bar of the splint or connected with a weight hanging over a pulley; this will drive the upper end firmly against the point of support. Counter-extension for the leg is obtained by tilting up the lower end of the bed, so as to utilize the patient's weight for this purpose. The limb itself is supported between the longitudinal bars as in a trough by securing to them bands of flannel, rubber or metal, by means of safety-pins or spring paper clips. Deflection of one or both fragments to either side can be corrected by passing a broad flannel band round the limb and drawing it to the opposite bar to which it is secured, or more certainly by the application of carefully padded hollow metal plates, fixed to the sidebars and with screw adjustments; sagging downwards of the fragments is corrected by tightening the bands forming the trough; displacement forwards, by passing a band above the limb and attaching it to either bar. In this way slight modifica-

tions are easily made. Sometimes the additional incorporation of short splints in front or behind is of considerable importance in steadying the parts. See also on pp. 579 and 607.

In the treatment of fractures where the tendency to displacement is slight (*e.g.*, transverse fractures), and where in children difficulties of fixation by splints occur, various forms of **Fixed Apparatus** are used; they are also of value in the later stages when other splints are not required. The materials most commonly employed are starch, water-glass, and plaster of Paris.

The *starch* bandage is utilized only in cases where great strength and rigidity are not required. After placing the fracture in good position, the limb is covered with boracic lint, and over this, if necessary, are applied thin strips of cardboard soaked in starch. These are firmly secured by bandages, into the meshes of which is rubbed a suitable solution of starch. When this dries, it produces a firm mass, sufficient to immobilize the limb. Should it become loose, it can easily be readjusted by slitting up and paring away a portion of one or both sides.

The *water-glass bandage* is applied by first swathing the limb with cotton-wool or with boric lint; around this a coarse canvas bandage is applied, soaked in a solution of silicate of soda of the consistency of treacle; several thicknesses of the bandage are required in order to give it the necessary strength. This material is light, easily applied, and makes very little mess, but is slow in drying, taking fully twenty-four hours to become firm.

Plaster of Paris, though rather messy and increasing considerably the weight of the limb, is one of the best means of securing prolonged immobilization. (*a*) The dried plaster may be rubbed into a coarse canvas bandage, which prior to use is soaked for a few minutes in cold water, to which a little salt or alum may be added in order to hasten its setting; it is then wound round the limb, which has been previously enswathed in boric lint or wool, and on the exterior of this fresh plaster of the consistency of cream is applied. To make this cream of the right strength the dried powder is cast in spoonfuls into a bowl of cold water, until it no longer sinks immediately, but remains floating on the surface. The mixture is then stirred with an iron spoon, and is ready for use. When the casing is sufficiently thick, the outer surface is smoothed down with wet hands, or a strip of wet bandage; the date may be advisably marked on it, and the part is slung up to dry. A Gigli saw, smothered with vaseline, may be incorporated in the dressing beneath the plaster, if it is desired to remove it early for the sake of massage, etc.; by this means it is easily cut into two pieces, which can be reapplied daily after the rubbing.

(*b*) Ordinary house-flannel forms the basis of various methods of applying plaster—*e.g.*, Croft's the Bavarian, etc. In the former the limb, protected by boric lint or wool, has applied to one side of it one or two thicknesses of flannel, suitably cut to shape, soaked

in plaster, and with perhaps a little extra plaster rubbed in; it is fixed to the limb by a muslin bandage. When this is dry, a similar splint is placed on the other side of the limb, and again bandaged on. Division of the bandage down the front permits the removal of the appliance, the bandage over the junction of the two portions behind serving as a hinge. If necessary, thin strips of wood or tin may be incorporated in any of these arrangements, so as to add to their strength.

(*c*) A much more cleanly method of using plaster is as follows: A double layer of lint is carefully fitted to the part to be immobilized. It is then laid on a table and opened out; over one-half of the lint are laid ten or a dozen layers of plaster bandage soaked in water, folded one over the other; the second layer of lint is then folded over the plaster bandage, which is thus enclosed between two layers of lint, as the ham between two layers of bread in a sandwich. This prepared splint still wet is applied to the limb and adapted to it by bandaging; fixation occurs quickly, and sufficient strength is present to prevent ordinary movements.

Early immobilization by means of plaster of Paris, reinforced by strips of wood or tin, has been advocated by certain authorities, constituting the so-called *ambulatory treatment* (see p. 630), and so much confidence have they in it that even fractures of the femur are dealt with in this way within a few days of the accident, and the patient allowed to walk about.

B. The increasing success of modern aseptic surgery has given considerable impetus to the **Early Operative Treatment** of fractures in order to secure perfect alinement, complete fixation, and the early restoration of function. This plan was first advocated and utilized by Lord Lister for such bones as the patella or olecranon, but its adoption for the long bones was largely due to the teaching and example of Sir W. Arbuthnot Lane.

The turning of a closed fracture into an open one is not to be looked on as a serious hindrance, granting that aseptic precautions are carefully observed; at the same time one cannot but recognize that an added element of risk is thereby introduced into the case. Possibly, in the more recent past, surgeons were more keen on developing their operative skill than on perfecting mechanical devices which shall avoid operation. One of the greatest lessons of the late war has been to emphasize once again the teachings of Hugh Thomas as to the value of the skeleton splint, and the adoption of this method of treating fractures in civilian life will limit considerably the operative activity of surgeons in this direction. Of course, the great advantage of operation is that it fixes the fracture so securely as to permit of early massage and movement of neighbouring joints; atrophy of muscles and stiffness are thereby avoided, and the economical depreciation in value of a working man after, say, a fractured tibia may be to a large extent prevented. One cannot but believe, however, that if similar care

is given to such cases treated on appropriate lines without operation, similar good results will be obtained. So long as the old-fashioned plan persists of fixing the joints above and below a fracture in apparatus troublesome to put on and take down, or in a rigid plaster of Paris case, until complete consolidation has occurred, and massage and movements are only employed to remedy stiffness already acquired, so long will bad results be turned out, and operative activity be justified.

The actual *selection of cases for operation* must necessarily vary with the views of the particular surgeon, but the following may be looked on as a fair statement of the case:

1. Fractures of small bones or of processes which are not easily retained in position by external appliances, and where healing apart from operation is slow and often defective—*e.g.*, in the patella, olecranon, etc.—require operation.

2. Fractures involving joints, where fragments are displaced, as when the condyles of the femur or humerus are detached, may sometimes be operated on with advantage.

3. Fractures of the shafts of long bones which are oblique or spiral, with much longitudinal displacement and perhaps overlapping, and with the sharp ends of the fragments impacted in muscular or other tissues, can often be placed in good position only by open operation, and even then perhaps with some difficulty. In situations where extension cannot be easily applied, and reduction by manipulation fails—*e.g.*, in some fractures of the forearm—operation is justifiable.

4. Fractures of the shafts of long bones which can be brought into good position by suitable extension should, as a rule, be treated by means of Thomas's splint or of some modification thereof, rather than by operation. Where effective extension can be made and maintained, an open operation may almost be looked on as a confession on the part of the surgeon of insufficient knowledge or inefficient apparatus.

The *time for operation* must be carefully considered; it is usually wise to delay it for a few days, partly to allow the patient to recover from the shock of the accident, partly to permit of effective purification of the limb and its radiographic examination, and partly to allow those early reparative changes to occur in the tissues of the part, which also assist in protecting them from infective troubles. Any time between the fourth and tenth days will be satisfactory. During the interval of waiting it is wise to apply effective weight extension so as to prevent any increase in the deformity and to reduce the amount of manipulation required at the operation.

The **operation** itself must be conducted with the most minute care as to aseptic precautions. The skin must be previously shaved and purified. Gloved hands are employed, and inasmuch as thin rubber gloves are easily penetrated by bone fragments, thick gloves may be used, or the thin gloves may be covered by sterilized cotton gloves. Spinal analgesia is often useful for the lower limb so as

to secure complete muscular relaxation. The incision should be planned so as to give effective exposure to the site of fracture, and allow exit to as much of the extravasated blood as possible. The surrounding skin should be protected by towels clipped on the wound margins, and of course no undue handling, even by gloved hands, should be permitted; to this end long-handled instruments have been devised by Lane and will be found advantageous. The ends of the fragments are exposed, cleared, brought into correct position with as little manipulation as possible, and held by suitable forceps, whilst their fixation is being accomplished. After this has been effected, the displaced periosteum is, if possible, drawn together so as to limit the field of activity of the osteoblasts and to prevent adhesions of the muscles to the bone; divided muscles are sutured together with deep sterilized catgut stitches; provision is made for temporary drainage if thought necessary; the deep fascia of the limb is carefully sutured, as also the skin. A suitable splint is then applied, and the patient returned to bed.

Various *methods of bone fixation* are available, and it is not always easy to determine which to employ. Much ingenuity has been exercised in the production of some of these, but most of them will be found in the near future rather in the Museum than in the operating room.

1. Sometimes it is sufficient to hold the fragments together by *silver wire* of appropriate thickness—*e.g.*, for the patella (Fig. 258), or olecranon, or for some oblique fractures of long bones. For the latter it is desirable to transfix the bone in two positions and introduce the wire as a mattress suture, and in a very oblique fracture two such sutures are desirable instead of one. Care must always be taken to tighten the wires securely by twisting, but not to twist off the ends; the knots must be bent over and beaten down, so as not to cause irritating projections.

2. When the fracture extends through masses of cancellous tissue, *e.g.*, the condyles of the femur, or has involved fragments covered with muscular origins, the complete displacement of which would be undesirable, *e.g.*, the condyles of the humerus, it is often possible to fix the fragment in position by *screws, nails, or pegs* of bone or ivory (Fig. 234). It is usually desirable to introduce two of these, so as to protect the fragment from displacement during the interval between withdrawing the drill and introducing the peg, as also to secure the fragment, when fixed, from rotation. Autogenous bone pegs, cut from the tibia by a double circular saw (*e.g.*, Albee's), and rounded by an electrically driven dowel-shaper, are more satisfactory than metal screws or nails; they are introduced into a suitable sized hole and driven home by a hammer, any excess being cut off, so that there is no projection.

3. *Intramedullary pegs* of metal or bone have also been employed, but are not so generally applicable, in that their introduction involves a good deal of displacement of the fragments; they do not secure so perfect an immobilization, and should the operation by mishap be followed by sepsis their removal is most difficult.

4. For fractures through the shafts of long bones, **Lane's plates** (Fig. 201) have been largely employed. They consist of flat metal plates which can be bent by suitable wrenches to fit accurately to the contour of the bone. They are supplied with a varying number of holes for screws, according to the type of fracture; holes are drilled through these into the bone, so as to reach the medullary cavity. For a fractured tibial shaft at least four screws are required, and for a femur six or eight.

Experience has, however, shown that there are many objections to their employment as a routine method of treatment, and they are now but little used. (*a*) It is essential to secure a firm hold of each fragment by the use of a *long* plate; this involves considerable interference with the soft tissues, thereby interfering with the nutrition of the bone. (*b*) Absolute fixity of the fragments without the possibility of the slightest movement does not conduce to rapid

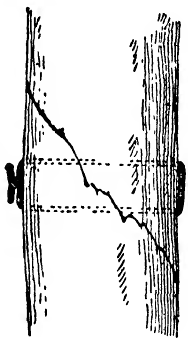


Fig. 200.—Fixation of Oblique Fracture by Silver Wire Loop traversing the Whole Thickness of the Bone.

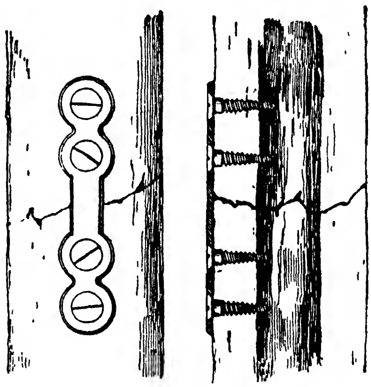


Fig. 201.—Lane's Plate applied for Transverse Fracture with Diagrammatic Longitudinal Section

or effective union; the best results are secured when it is possible for the ends to rub one against the other without displacement. Non-union in the ribs is unknown; delayed or non-union after 'plating' is not uncommon. (*c*) The local effects of the screws on the bony tissue is to cause rarefaction, so that the firm hold is lost in a short time. If splints or other retentive apparatus are removed too soon, so that powerful muscles can come into action, displacement and deformity may readily appear, especially in the shaft of the femur. (*d*) Infection of the wound is almost always associated with death of the portion of bone lying under the plate, and may reach the medullary cavity through the screw holes. Delayed auto-infection may also occur, arising in the small hæmatoma or from the damaged tissues around the plate. (*e*) It is hardly needful to say that metallic plates should never be used for an open fracture, unless it has been demonstrated to be sterile.

5. **External clamps** connected with long removable screws have been advocated by some authors, *e.g.*, Hey-Groves, but their employment is not generally recommended or feasible.

6. In conclusion, one would note that all metal appliances are undesirable in the fractures of children; silver wire is the least objectionable; nails and screws, especially near joints, may light up inflammatory mischief; the screws of bone plates are early loosened by rarefying inflammation, so that this proceeding is not very reliable; catgut or silk sutures passed through the periosteum so as to hold the fragments temporarily in position or autogenous bone pegs should be chiefly relied on. Every effort must be made, however, to avoid operation for fractures in children.

III. **Massage and Mobilization** nowadays play an important part in the treatment of fractures. The days of prolonged splinting and immobilization are over (or should be), and splints are looked upon as undesirable necessities to be discarded as soon as possible and replaced if need be by light removable plaster of Paris supports, which protect from injury and displacement a weakly united fracture between the intervals of exercise and massage. Under the old régime the functional results of treatment were extremely bad in the aggregate; the limb remained for a considerable period weak and stiff, owing partly to atrophy of muscles, partly to cicatricial adhesions, and in part to contraction of ligaments in neighbouring joints, and these disabilities increased in direct ratio to the length of time that the limb had been kept at rest. The modern surgeon endeavours to prevent these disabilities, but this can only be effected by persistent attention and methodical after-treatment.

In the earliest stages massage may be employed in the shape of gentle stroking movements to relieve pain and diminish muscular spasm. Thus diagnosis is facilitated, since the patient permits the limb to be handled and gentle movements to be undertaken, and reposition of the fragments may become practicable.

In fractures through the shafts of long bones with displacement, which, apart from operation, may possibly recur, the part is necessarily immobilized by a suitable appliance; but although the joints above and below the lesion are included in the apparatus, there is no need to keep them immobile throughout the course of treatment. Indeed, it is most desirable that from a very early date they should be moved regularly, and thereby stiffness prevented, and with modern appliances of the Thomas type this is perfectly feasible. Massage is employed in these cases to tone up muscles, as well as to assist in the absorption of blood, etc. Possibly some pain is noticed at first, but it soon disappears if the massage is gentle and not too forcible. Of course, the patient is not allowed to put any strain on the part by active movements until the consolidation of the fracture is assured. Where the tendency to displacement has been remedied by operation, the whole proceeding is necessarily easier.

In fractures near joints or through the articular ends of bones it is often possible, and indeed wise, to discard splints entirely, or

at any rate only to use them for a short time, steadying the part by some simple contrivance, such as a sling or strapping; massage is commenced after the first few days, and if of the gentle and soothing type is most comforting, and will enable the neighbouring joint to be moved passively. This method of treatment is specially applicable to such injuries as fractures of the anatomical neck of the humerus, the simpler varieties of Colles's and Pott's fractures, and for many fracture-dislocations in the neighbourhood of the elbow. In such cases active movements may often be permitted at quite an early date; but if these are produced by powerful muscles, which by their attachment to one of the fragments are liable to reproduce the deformity, then passive movements and massage must be relied on until the fracture is consolidated, and there are conditions about the elbow where even passive movements must be refrained from for a time. In spite of all precautions, however, a certain percentage of cases under this heading are certain to develop permanent stiffness to a varying degree.

In fractures where there is no displacement, one need hardly point out that splints are not required. All that is needed is to protect the part so that the lesion is not aggravated, and to encourage union and promote functional repair by massage, etc. Thus where a tibia is broken across without displacement, the patient is kept at rest, but is permitted to move all joints freely so long as he avoids the strain involved by carrying his own weight.

Finally, a word of caution must be given against too forcible and vigorous massage and movement, which can readily induce pain, muscular spasm and increasing stiffness. This is particularly the case when the line of fracture involves a joint, and then natural movements carefully graded are often more valuable than forcible passive exercises. The onset of pain as the result of massage or movement is always an indication to keep the parts at rest for a few days longer.

Complications of Fractures—1. **Implication of a Joint.**—When the fracture extends through the articular cartilage, the joint becomes distended with blood and synovial fluid, but this is subsequently absorbed, and the fissure in the cartilage closed by plastic lymph, which develops into scar tissue. If the fragments are in perfect apposition, no permanent harm need result if treatment such as that recommended above is undertaken. If, however, the apposition is imperfect, adhesions of a more serious type develop, and considerable limitation of movement may follow. It is thus comprehensible that one of the chief indications for the operative treatment of fractures is when they involve joints. In elderly people injuries of this type may result in a chronic traumatic arthritis, particularly in the shoulder or hip, causing pain and limitation of movement by the development of osteophytes. In some of these cases massage seems to do harm rather than good.

2. The same violence that causes the fracture may at the same time produce a **Dislocation** in a neighbouring joint, and particu-

larly in connection with the elbow and shoulder. Treatment should always be undertaken as soon as possible. Should the fracture involve or be close to the articular end of the bone, an attempt should be made to reduce the deformity by manipulation under an anæsthetic; failing this, or if the deformity recurs, open operation should be undertaken if the conditions as to surgical cleanliness permit. In most cases the dislocation can be reduced after removing the extravasated blood, and the fracture fixed: but sometimes, when the displaced articular fragment is small, it is wiser to excise it.

When the fracture is further away from the joint, it is sometimes possible to command the fragments by splints, and then reduce the dislocation under an anæsthetic. Should this fail, the surgeon may either fix the fracture by operation and repeat the attempt to reduce the dislocation, or he may open the joint and perform an open reduction. Should immediate treatment be impracticable, the limb should be fixed in splints so as to allow union of the fracture, and at a later date the unreduced dislocation should be treated.

3. The **Main Artery** may be compressed, contused, punctured, or ruptured, giving rise to thrombosis, aneurism, or hæmorrhage. In the former case dry gangrene may result if the terminal vessels are unhealthy; in the latter moist gangrene may be produced by the pressure of the extravasated blood on the veins. This is most frequently observed in fractures of the lower end of the femur, where the femoral or popliteal artery may be involved. **Treatment** has been discussed elsewhere (p. 125). Here it may only be mentioned that in the case of a ruptured artery operation should, if possible, involve not only the removal of the blood-clot and the securing of the artery, but also the fixation of the fracture.

4. Laceration of **Veins** results in extravasation of blood, which is not so extensive as when an artery is wounded, since thrombosis occurs more easily; the distal part of the limb may become congested and œdematous, and this may require for its removal firm bandaging and massage. Pulmonary embolus is an occasional sequence of venous thrombosis.

5. The **Nerves** of a limb may be injured at two different periods. (*a*) Immediate injury is due to laceration or rupture, either of the whole trunk, or, as is more common, of the nerve fibrillæ, without loss of continuity of the sheath. (*b*) Secondary symptoms result from inclusion and compression of the nerve in the callus, or from injudicious splint pressure. Irritative symptoms in the shape of neuralgia are first manifested, followed by paralysis and anæsthesia. This usually occurs three or four weeks after the accident, and may disappear in a month or two, or persist. **Treatment** is always for a time of the expectant type, even when the paralysis is immediate, since total rupture of a nerve is rare, and restoration of function the rule rather than the exception. When, however, the symptoms persist, the parts must be laid open, the nerve freed from adhesions, or exuberant callus removed, and such measures taken as will best secure the nerve from further compression (Chapter XVI.).

Complications arising during Treatment.—(1) If an elderly patient is kept in bed for any length of time in the recumbent posture, *hypostatic pneumonia* is likely to ensue. It occurs most commonly after intracapsular fractures of the cervix femoris, and non-union often results, since the patients must be allowed to get about on crutches at an early date with the limb fixed by a suitable splint. (2) *Bedsores* (p. 126) are liable to supervene in old people with fractures which need treatment in the recumbent posture. (3) *Crutch palsy* is the result of compression of the brachial nerves between the head of the humerus and the pad of a crutch. It may affect all the nerves of the upper extremity, or may pick out any one of them, and then most commonly the musculo-spiral. It can usually be prevented by the use of spring-padded crutches with cross-pieces for the hands, so as to allow the patient partially to relieve the axillary pressure by supporting the weight of the body by means of the arms, or by the employment of the modern stick-crutch. When it has occurred, the use of crutches must be discontinued, and faradism and massage employed to the affected muscles. (4) *Volkmann's contracture* (p. 461) sometimes develops in cases of fracture of the forearm or elbow in children. (5) Another muscular complication consists in a deposit of bony tissue therein, a result of a *myositis ossificans* (p. 463) (6) *Gangrene* may arise from fractures in a variety of ways: (i.) From the immediate effects of the injury, either by its direct action on the tissues, or by causing arterial thrombosis in a limb with atheromatous vessels, or from rupture of the artery with consequent venous thrombosis, owing to the pressure of the extravasation; (ii.) by the supervention of spreading gangrene in a compound fracture; (iii.) from errors in the course of treatment, as by bandaging the limb too tightly, so as to constrict the vessels; or by the bandage becoming unduly tight, owing to the subsequent swelling of the limb; or by flexing a joint after bandaging it, the bandage cutting into the soft tissues; or by the localized pressure of a splint which has been insufficiently padded. Moist gangrene is the type met with in all cases, except when the limb has been previously drained of its fluid by an atheromatous condition of its vessels. (For rules of treatment, see Chapter VI.)

(7) *Splint sores* constitute a form of localized gangrene due to the pressure of a badly fitting or imperfectly padded splint, or possibly to bandaging on too tightly a splint which otherwise would be satisfactory. The commonest situation is over the heel when the limb has been kept for a time on a back splint with a foot piece; it is also sometimes seen on the outer or inner side of the leg when side splints have been too firmly applied. When of considerable size, the parts must be purified carefully, all pressure removed, and antiseptic fomentations applied to assist in the removal of the dead tissue; the sore resulting therefrom will require stimulating applications to encourage healing. When the slough is of small dimensions, it is kept aseptic and allowed to be absorbed by natural processes.

Open (or Compound) Fractures.

An open fracture is one in which there is a communication between the external air and the site of injury. It is caused by direct or indirect violence, the solution of continuity of the skin being produced in the former from without, and in the latter by the penetration of a bony fragment from within. It is also sometimes secondary to treatment, the skin over the fracture sloughing as a result of pressure or irritation. The bone may be but little displaced, or may protrude through a small opening in the skin; or the bone may be crushed and comminuted, and a large fleshy wound may be associated with it. In some of the injuries produced by railway or machine accidents, gunshot wounds, or motor-cars, the skin and muscles are violently torn across, and the underlying bone may be pulped, whilst road-dust, grease, and dirt of many types are ground into the tissues.

The chief peculiarities of open fractures are due to the existence of the external wound, which permits of the entrance of bacteria into the depths of the limb, and perhaps interferes seriously with the application of splints and other appliances.

Hæmorrhage occurs to a variable degree according to the size of the vessels involved; but inasmuch as the lesion is not usually produced by cutting, the vessels may become sealed by natural processes. Secondary hæmorrhage is not uncommon in septic cases, as the result of a periarteritis, particularly if a sharp fragment lies in close contiguity to a large vessel (Fig. 95).

Infection is caused by any of the multifarious types of germs found in the skin, dirty clothes, road dirt or soil. The ordinary pyococci are almost always present together with anaërobes, coliform bacilli, and organisms of the proteus type. Any or all of the parts involved may become the seat of suppurative lesions which have a considerable tendency to spread. Thus cellulitis may develop in the subcutaneous tissues, and erysipelas sometimes occurs. The deeper planes of cellular tissue are also involved, and this may be followed by wide burrowing of pus. The possibility of the development of tetanus must also be remembered.

Muscle bellies often protrude through the opening in the deep fascia by which they suffer constriction, and present as an œdematous mass which may even become gangrenous; drainage of the deeper parts of the wound is thereby hindered. Anaërobic invasion may lead to localized gas gangrene.

Tendon sheaths, if opened, provide a favourable nidus for the development of pus organisms, and the suppuration may track up or down for a considerable distance; the tendons themselves slough or contract dense adhesions to the sheath.

The effect on the *bone* varies. If the shaft is broken cleanly, an acute osteomyelitis may follow if drainage is defective; but if there is a free exit to discharges, all that may result is a limited necrosis of the compact tissue of the end of one or both fragments.

If the fracture involves cancellous tissue, an acute infective osteitis follows, leading to cario-necrosis, and possibly by direct extension involving neighbouring joints and bones. The existence of *fissures* extending from the main focus of the lesion does not necessarily involve a spread of the suppuration along them, unless rough handling, or injudicious movement, or tension from want of drainage, is present. When *comminution* is present, infection almost invariably leads to death of all totally detached fragments, but those which retain their periosteal connection will probably live and be useful in the reparative process if satisfactory drainage is established.

Neighbouring joints may become infected at the time of the original injury, or subsequently by secondary extension through living bone or along fissures. In old-standing cases with necrosis and chronic sepsis, joints may become stiff by prolonged immobilization, and then forcible attempts to break down adhesions and free the joint may result in lighting up an acute suppurative arthritis.

Nerves may be injured at the time of the accident, or damaged at a later date by inclusion in the callus or in cicatricial tissue. The phenomena are identical with those following a simple fracture, but unfortunately nothing can be done in the operative line to repair them until the sepsis has been overcome.

It will be manifest from the above brief generalization that whilst compound fractures may be followed by good results if treated early and effectively, delay or defective treatment may involve the patient in the gravest dangers of an infective nature (pyæmia, septicæmia, etc.), or may lead to a most wearisome and prolonged convalescence. Life and limb are alike threatened, and even if both are saved great and crippling disability may follow.

The **Method of Repair** of a compound fracture is much the same in principle as that of the simple variety, but necessarily is largely influenced by the *course of the case*.

If complete and immediate sterilization of the wound can be effected, it may be closed at once or by delayed primary suture, and the fracture treated in the same way as one with no skin involvement. The repair is then identical in the two types. The same occurs if infection merely involves the soft tissues.

If, however, bacteria invade the bony fragments, a certain amount of necrosis is almost sure to occur, and delay in healing of the wound must ensue whilst the necrosed fragments are separating. (i.) If the fracture is *a clean break through the shaft*, and the necrosis limited to a small section of the compact tissue on one or both fragments (Fig. 202), the dead bone is separated by a process of rarefying osteitis in the neighbouring compact tissue; the marrow cavity is shut off by a medullary plug of soft bone, the superficial layer of which is converted into granulation tissue. Whilst this is occurring, new bone is being formed from the osteoblasts adherent to the neighbouring periosteum, and this may suffice to bridge the gap between the fragments and determine their union. The bond of union thus formed constitutes an involucrum (p. 638) to the dead

bone, which lies within and is gradually separated. If the sequestrum is small, it may find its own way to the surface, but usually the external wound has narrowed to such an extent during the interval as to prevent its escape, and sequestrotomy must be undertaken. When once the sequestrum is removed, a clean granulating cavity persists, and this should heal more or less quickly according to its shape and blood-supply; the deeper part of the granulations being derived from bone is likely to develop into bone; the more superficial part, into cicatricial tissue.

Sometimes, however, the presence of the sequestrum maintains so much irritation that reparative changes cannot occur so long as suppuration persists, and the fracture remains ununited; removal of the sequestrum may bring about such a degree of healthy action as to determine union.

FIG. 202.—DIAGRAMMATIC REPRESENTATION OF A COMPOUND FRACTURE WITH NECROSIS OF THE ENDS OF THE BONES, UNDERGOING CONSOLIDATION AT THE SAME TIME AS THE NECROSED FRAGMENTS ARE SEPARATING.

(ii.) *In cancellous bone* a septic fracture will be followed by a spreading osteitis until efficient drainage is provided, and then the destructive process comes to an end and repair follows.

(iii.) *Comminution* of compact tissue is a serious complication in an infected open fracture. Fragments totally detached die, and, unless they are removed, cause persistent suppuration. Fragments retaining their periosteal connections live, and undergo active changes, either destructive or reparative, according to the degree of infection present. Where drainage is free, the fragments are welded together by granulations around the central cavity of the fracture, and these granulations are converted into new bone.

In cancellous tissue a similar process occurs when the parts are freely opened up and drained, and all loose fragments removed. Too conservative a policy results in the retention of both dead and living fragments, between which pus burrows, coming to the surface in various directions, so that the whole area of the injury may be riddled with sinuses. Some degree of reparative activity occurs, and in time the site of the injury may be occupied by a swelling, which consists of a curious mixture of dead and living bone, more or less carious, between the constituent elements of which lies a mass of œdematous tissue, partly granulation, partly cicatricial; sinuses track through this mass, and the patient may become gravely ill and anæmic from toxic absorption. No repair can be expected so long as this mass persists, and cure can only be established by clearing out the whole infected area.

The **treatment** of compound fractures has two main points in view

—viz., (1) To prevent the development of infection or to limit its ravages, and (2) to fix the limb in apparatus, so that repair of the bone may occur with as little deformity as possible.

The prevention of infection is really a question of time; if the case is seen early, much can be done; if there is much delay, sterilization of the wound is almost impossible. The rules already given (p. 86) must be followed out with the greatest care. The skin of the limb is shaved and purified; the margins of the wound are excised; the cavity of the wound is laid open by suitable incisions, so that the interior may be thoroughly explored. Damaged and hopelessly torn tissues are cut away so as to leave a free approach to the site of the fracture, which is appropriately dealt with. If the surgeon is satisfied, he may close the wound entirely, or may wash it with alcohol and 'Bipp' it before closure. If he is doubtful as to the result of his efforts, the Carrel-Dakin treatment may be instituted, or a flavine pack inserted—but in the latter case the gauze must not be entangled in the spicules of the bone. A counter-opening may be necessary, but *under no circumstances must a drainage-tube be carried across the site of the fracture so as to lie between the fragments;* necrosis is certain to follow such a procedure.

Winnett Orr of America has produced some astonishing good results by thoroughly cleaning up the wound and packing it with sterile vaseline, after the bone or bones have been brought into alinement by manual or skeletal traction. No attempt is made to close the wound, nor is any drainage employed. The limb is encased in plaster of Paris. The plaster is not removed for six weeks or more, when it is found the wound will probably have healed.

The treatment of the bone itself varies with circumstances. When merely a sharp end of one of the fragments protrudes through a small opening in the skin, the latter is first purified thoroughly, and then after the margins have been excised and the wound, if need be, enlarged, reduction is effected, and the wound, if thought desirable, closed. In clean breaks without protrusion, the fractured ends are apposed in the usual way and the limb placed on a suitable splint. Skeleton splints of the Thomas type are of the greatest value in compound fractures, in that the limb need not be disturbed when the wound is dressed; the flannel bands which constitute the trough in which the limb lies must be so arranged that by the removal of one or more easy access to the wound is secured.

When comminution is present, the site of the fracture should be carefully explored. All totally detached fragments are removed, but the majority of fragments which retain their periosteal attachments, especially if of large size, are saved. If the surgeon is fairly confident as to sterilization, no removal of bone other than of completely detached fragments is justifiable; if, however, he anticipates infection, or if it is already present, he should remove by careful subperiosteal resection such loose fragments as are likely to hinder effective drainage, always leaving a sufficiency of bone to maintain the continuity of the limb.

When suppuration persists, necrosis has probably occurred, and radiography is useful in determining when the sequestrum is free. It must be remembered, however, that sequestra seldom take more than two or three months to separate, and often less. As soon as separation is effected, operation to remove the sequestrum must be undertaken; delay involves thickening and condensation of the involucrum, with subsequent trouble in determining closure of the sequestral cavity (p. 646).

All secondary operations required for non-union, vicious union, or nerve lesions must be postponed till the wound has been satisfactorily healed for some time.

The question of *amputation* has, of course, to be considered in many cases, both immediately or as a secondary procedure, and has been discussed elsewhere (p. 262). It is only necessary here to remind practitioners that so much can be done nowadays by conservative means that amputation must not be decided on without the most careful consideration; at the same time it is useless to retain that which may become a source of serious danger, or even if saved remain a useless encumbrance.

As a secondary operation, amputation is needed mainly for severe recurrent secondary hæmorrhage, grave infection of the soft parts extending up the limb with marked toxæmia, a heavy infection of a neighbouring joint or of surrounding bones (as in the tarsus), or chronic anæmia and toxæmia due to persisting and long-continued suppuration. Gangrene from whatever cause also requires amputation, but not necessarily up to the site of fracture.

Chronic necrosis has been unfortunately a sequela seen only too commonly after compound fractures due to gunshot wounds, and there can be no question that for some years these cases will require treatment. The unfortunate patient retains one or more suppurating sinuses, from which perhaps small spicules of bone are discharged; this may be followed by healing which persists for a time, and then possibly, as the result of some slight injury, the wound flares up, the limb swells, and the cicatrix gives way, permitting exit to a quantity of pus. A probe is passed, and finds its way into a bony cavity along a passage which may be straight or tortuous; bare bone is touched; and the doctor not unfrequently decides to 'scrape it out.' This is done more or less thoroughly, probably through a small incision; fresh bony tissue is laid bare and infected; fresh necrosis follows; and the whole gamut of trouble is repeated. This goes on time after time, and operation follows operation for years perchance, and at the end of fifteen to twenty operations the patient is in a rather worse condition than previously, and frequently requests the removal of his limb.

The local conditions present in these cases vary considerably, but as a rule there is a sequestrum of greater or less size lying in a cavity which is almost surrounded by bone, which becomes increasingly dense and non-vascular as the months pass, until sometimes it is as hard as ivory. It is obvious that reparative changes can

only occur very slowly in such tissue, and that scraping cannot be expected to bring about healthy activity. The sinuses which reach this cavity are often narrow, and may be badly placed for drainage or dressing; the constant passage of discharges and the daily introduction of gauze packing (often too tightly) suffice to determine a spreading sclerosis in the surrounding soft tissues which will impair subsequent usefulness. Even if the sequestrum is taken away successfully without waking up fresh trouble, healing does not always occur, since the bone may be tunnelled, and the sides of a bony tunnel necessarily cannot fall together.

The treatment of these cases is often very difficult, and usually irksome both to doctor and patient, and yet they can be cured even after many futile operations.

The actual operative procedure must be governed by the following considerations: (1) A careful stereoscopic skiagram of the limb must be secured, which shall enable the surgeon to visualize clearly the conditions he is called on to treat. (2) The trouble in the bone must be approached by a route which shall enable him effectively to deal with it; if the existent sinuses happen to fall into the line of his incision, well and good; if not, the sinuses will probably close quickly after the essential cause of the trouble has been dealt with. (3) The incisions must be sufficiently long to enable *all* the trouble in the bone to be reached and dealt with openly without recourse to a curved spoon, which can scrape round a corner and only just get into a narrow passage. The ideal condition to be left after operation is a wide shallow gutter or crater with no overhanging bony lips. This necessarily involves the cutting away of a good deal of bone in many cases, for which suitable chisels and gouges are required; but the dense bone often found is very unfavourable for reparative purposes. Tunnels in the bone are treated, if practicable, by removing entirely one side of the tunnel so as to convert it into a trench into which the surrounding soft tissues may find an entrance.

The cavity thus formed is carefully dried, hot saline solution being employed as a hæmostatic; it may then be wiped over with absolute alcohol, and packed with gauze soaked in 'Bipp,' which is retained for ten days or more unless there has previously been very free discharge. If there is little discharge, frequent dressings are quite unnecessary, and indeed harmful; probably it suffices to change the 'bipped' gauze once in ten days. Occasionally the surgeon may feel justified in closing the cavity entirely after 'bipping' it, but this is not often possible. Other methods of closing the cavity in the bone are alluded to at p. 646

Ununited Fractures.

Three varieties of ununited fracture have been described: (1) *Absolute non-union*, when no attempt at repair is made, may result from fractures due to the presence of some local disease which has led to wide destruction of bony tissue, such as sarcoma or osteomalacia, or from the resection of extensive areas of bone for sarcoma or gun-shot injuries. (2) *Fibrous union* consists in the development of a more or less firm mass of connective tissue as the bond of union between the ends of the bones, which are either rounded off and closed by a thin plate of bone, or cartilage, or are sometimes atrophic and pointed. (3) A *false joint*, or *pseudarthrosis*, is a condition in which the ends of the fragments are covered either by bone or cartilage, and more or less altered in shape, so as to form a shallow ball-and-socket joint, the capsule being represented by the surrounding fibrous tissue, and the synovial cavity by the formation of an adventitious bursa.

The most common situations for ununited fractures are projecting processes of bone to which powerful muscles are attached, such as the patella, olecranon, coracoid process, posterior half of the os calcis, etc.; whilst in long bones the middle of the shaft of the humerus and the upper and lower thirds of the femur are the favourite sites.

Causes.—(1) Want of apposition of the bony ends, owing to extensive resection, or to muscular action, *e g.*, in the patella, when the two fragments are widely separated, or in the femur, where they may overlap; (2) the interposition of muscular or aponeurotic tissue, or detached fragments of compact bone; (3) want of support, one of the most common mistakes in the treatment of fractures of the middle of the shaft of the humerus, where, unless the weight of the forearm and lower fragment is suitably supported, apposition of the fragments is likely to fail, and non-union to result; (4) defective blood-supply to one or both fragments, as by injury to the nutrient artery, or as in transcervical fracture of the cervix femoris, where the only source of supply to the upper fragment is a small twig derived from the obturator artery running along the ligamentum teres; (5) local affections of the bone, such as suppuration with necrosis in compound fractures, malignant tumours, or the undue pressure of pads upon newly-formed callus; (6) general bone disease, as osteomalacia; and (7) general constitutional weakness or debility, and diseases such as scurvy or severe syphilis.

The **Signs** of an ununited fracture are usually obvious, mobility between the fragments being easily obtained in some directions, though perhaps not in all; of course, crepitus is absent. It is perfectly possible, however, for a person with good muscular development to have an ununited fracture with but little functional disability; the condition may be obvious when the muscles are relaxed, but disappears when the muscles contract. In doubtful cases radiography will help in diagnosis.

The **Prognosis** is fairly good if suitable treatment is adopted, and the local or general conditions do not prohibit reunion. In particular, emphasis must be laid upon the necessity for patience in the non-union associated with infected open fractures. Until all necrosed tissue has been removed, and the infection overcome, reparative processes are often slow in being established. If the parts be fixed, and the vascularity of the limb increased by massage and the use of such portions of the limb as can be moved without displacing the fragments, and if the general health be improved, repair without operation can often be established in time. Operation itself is not always successful, especially if the soft parts have to be extensively interfered with in order to secure reposition of the fragments; in

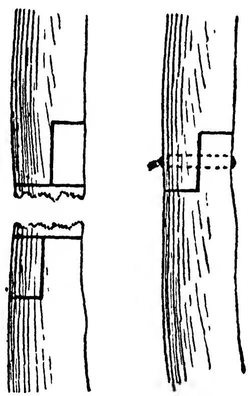


FIG. 203.—'STEPPING' OPERATION FOR UNUNITED FRACTURE.

Having freed the ends of the fragments, a saw cut is carried across the end to make certain that bony tissue is exposed. The saw (possibly a butcher's) is next carried longitudinally up the centre of the shaft to a sufficient distance, and the small fragment loosened by a Gigli saw. The same process is performed on the other fragment, and the wire mattress suture is then introduced through holes previously made. Exact and accurate fitting of the fragments is essential for good results.

children, under such circumstances, the outlook is poor, the ends of the bone becoming atrophic, rounded, and covered by cartilage; in such the final resource is not unfrequently amputation.

Treatment.—(1) If in good position, the parts should be refixed, and a course of passive venous congestion carried out. A Bier's elastic bandage is applied to the limb above the fracture for three or four hours daily. Excellent results often follow. At the same time the general health is improved by a stay at the seaside or the administration of tonics, and the condition of the limb improved by massage. If an external support can be arranged so as to enable the patient to use the limb, though the fracture is still ununited, so much the better; it may stimulate the bone-forming power of the fragments.

(2) Failing this, operative measures must be undertaken. If the bone is tolerably superficial, and the ends not very far apart, they should be exposed, sawn into shape, fitted together, and secured by catgut sutures, silver wire, or pegs. To effect this a free incision in a line of safety is necessary, taking special precautions to protect not only the main nerves, but also their muscular branches. The ends of the bone are carefully examined, and suitably cut into shape so as to secure effective coaptation. One of the simplest and best methods is to cut 'steps' in the bone ends by a saw (Fig. 203) and to fix the fragments by a catgut or wire mattress suture. The limb is shortened somewhat by this means, but firm union is secured, and the delay and doubts associated with bone grafts are avoided. See also below, *re* 'flail-arm.'

(3) If, however, the bones are deeply placed, so that it is difficult to expose the ends and fit them together, it may be wiser to leave them in their bad position, and fix them by the insertion of autogenous bone pegs, or failing this by screws or ivory pegs. Thus, in the upper end of the femur, non-union is usually associated with over-lapping of the fragments to a considerable extent. To expose and fit these together would necessitate a very extensive dissection; it may be desirable in such cases merely to cut down in front upon the upper anterior fragment, drill two holes in different directions through both fragments, and into these insert suitable pegs or screws. Two holes should always be employed, to prevent slipping of the fragments during the necessary manipulations; whilst one drill is removed for the insertion of the peg, the other holds the bone steady. Their presence causes the formation of a large amount of callus, and by this means the fracture is consolidated. Of course, this procedure involves the persistence of shortening, and in young and healthy adults it is probable that a more extensive operation with complete reduction and fixation of the fracture is advisable; but unless the local and general conditions are good, the above procedure may suffice.

(4) When there is loss of substance between the bone ends and other operative measures fail, various methods of bone-grafting may be employed (p. 678).

The problem as to how to treat the **flail-arm** resulting from the resection of extensive areas of bone for gunshot wounds is one that has recently exercised many surgeons. The condition occurs most frequently at the upper limit of the arm due to removal of the head of the humerus and a good portion of the shaft, or in the neighbourhood of the elbow, the shattered bone ends having been widely exsected. (1) It is necessary to support the limb after the original operation and during convalescence in such a manner as to encourage accommodative shortening of muscles, etc.; to permit the arm to hang without support must obviously result in stretching of these muscles by the weight of the limb. This support should rest on the shoulder above, to which it is carefully fitted, and should grasp the elbow or forearm below. (2) During the period of waiting which must supervene before further operation is feasible, the biceps and triceps must be toned up daily by electrical treatment (sinusoidal

current), and encouraged to contract, thereby diminishing the gap between the bone ends. Skilful operative treatment directed towards the bones will prove to be useless unless the muscles have been previously treated in this way; they cannot contract and control distal parts if they are slack. (3) The actual details of operative treatment must vary in different cases, but essentially it consists in approximating the bone ends sufficiently to permit of the introduction of silver wire or a plate, which shall hold the ends together. Thus the lower end of the humerus may be pushed down and wedged into the hollow of the olecranon and there fixed; the upper end of the humerus may be attached to the lower lip of the glenoid cavity, or to the acromion process which has been sawn through and turned down. Occasionally simple bone grafts will suffice to secure fixity, and sometimes these grafts may include such structures as a complete joint, but our experience is not yet sufficient to justify any dogmatic statement.

Disunited Fracture is the term applied to a rare condition, in which a fracture which had been firmly united becomes separated again. It is only met with when the individual develops some extremely debilitating disease, such as scurvy, and may be recovered from under suitable treatment directed to the cause, and by fixation of the parts.

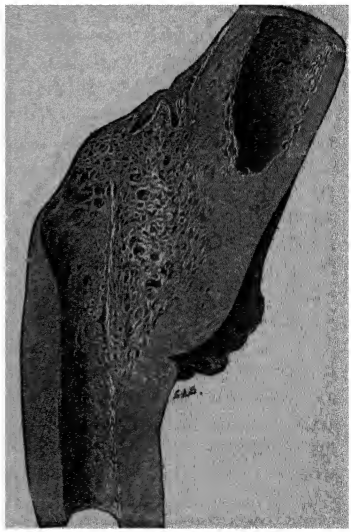


FIG 204.—VICIOUS UNION WITH MARKED DEFORMITY AFTER FRACTURE OF FEMUR. (KING'S COLLEGE HOSPITAL MUSEUM.)

Vicious Union (Fig. 204) of fractures results either from imperfect adjustment of the ends of the bone, or from the parts not being kept at rest, and hence becoming subsequently displaced. The difficulty of managing serious compound fractures explains the frequency with which vicious union is seen after gunshot wounds. Various kinds of deformity and disfigurement, accompanied or not by loss of function, may result, and if these are serious, means must be taken to remedy matters. If observed early, when the callus is not too consolidated, it is not difficult forcibly to readjust the parts by manipulation under an anæsthetic—if necessary refracturing the bone. In some cases powerful mechanical appliances, or osteoclasts, are employed for this purpose, but care must be exercised not to damage unduly the soft parts. The *open* method is certainly preferable, cutting down on the bone, redividing it, removing redundant callus, and fixing the fragments by silver wire, pegs, or screws. Of course, after septic gunshot wounds the usual precautions as to delay and preliminary vaccine treatment to protect against infection must be observed.

Special Fractures.

Bones of the Face.—The **Nasal** bones are broken as a result of direct violence—by the fist, a cricket-ball, stick, etc. The fracture is generally transverse, and situated just above their free margins; occasionally, when greater force is used, it occurs close to the root of the nose, and may then be associated with fracture of the frontal bone or base of the skull (R.S., Fig. 5). In young people the cartilages alone may be separated. There is usually considerable deformity from depression or lateral displacement of the fragments, although it may at first be masked by the amount of bruising. Severe epistaxis, surgical emphysema, and cerebral symptoms, are sometimes met with as complications. The fracture very readily becomes consolidated, and the deformity is thus often irremediably fixed, unless its presence is determined at once, and suitable treatment adopted. The **Septum** is sometimes broken and depressed, in association with or apart from the above injury. Lateral displacement occurs, causing unilateral nasal obstruction and some amount of obvious deformity. The **Treatment** of these cases consists in immediate replacement of the bones, advisably under an anæsthetic; this may be accomplished by the pressure of some blunt instrument, such as a pair of dressing forceps, the blades of which, covered with rubber, are introduced within the nostril. A pad of lint or gauze soaked in carbolized oil is, if necessary, inserted to maintain the position, and a gutta-percha or zinc splint moulded to fit the bridge. This dressing should be changed at least every twenty-four hours, and the nose irrigated.

The **Lachrymal** bone has been broken by direct violence, the fracture usually extending from the nasal bone to the lateral mass of the ethmoid. Interference with the flow of tears and surgical emphysema are the two most marked symptoms.

The **Malar** bone is but rarely broken without the other bones of the face being involved; fracture is almost always associated with damage to the anterior wall of the antrum and considerable depression of the fragments. An attempt should be made to replace the parts by pressure from within the mouth.

The **Zygoma** is fractured by direct violence applied from without; the broken portion may be depressed below the surface, but vertical displacement is limited by the attachment of the masseter below and of the temporal fascia above. Reposition, either by manipulation from within the mouth, or even by operation, is essential in order to prevent interference with the subsequent mobility of the jaw. Perhaps the simplest plan to adopt is to encircle the zygoma subcutaneously with a loop of silver wire and drag it up to its natural level.

The **Superior Maxilla** is invariably broken as a result of direct injury, such as a blow or gunshot wound; it is almost always compound, and often bilateral. The alveolar portion is either partially or entirely detached, or a transverse fissure, extending as far as the pterygoid processes on each side, may render the whole palate and

lower part of the facial skeleton movable. More frequently all the bones of the face are smashed and comminuted, severe hæmorrhage sometimes resulting from wounds of the terminal branches of the internal maxillary artery. **Treatment** consists in merely keeping the patient quiet and applying cooling lotions; union occurs with great readiness, but is sometimes associated with suppuration and necrosis. The patient must be fed by a tube, and a carefully-fitted dental plate should be applied to a broken alveolus after removal of the teeth which penetrate the affected region.

The **Inferior Maxilla** is usually fractured by direct violence applied from in front, as by a fall or a 'punch' on the chin; more rarely the force acts from the side, and then the bone may break in the middle line. Most frequently, however, the lesion is a little in front of the mental foramen in the neighbourhood of the canine tooth (Fig. 205), this being a weak spot at the junction of two strong parts, viz.,

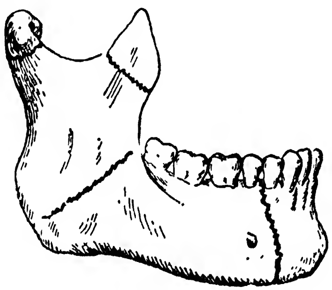


FIG. 205.—LOWER JAW, INDICATING THE MOST COMMON SITES OF FRACTURE.

FIG. 206.—APPLICATION OF FOUR-TAILED BANDAGE FOR FRACTURE OF LOWER JAW.

the symphysis menti, and the alveolar process carrying the molar teeth. This fracture is occasionally bilateral—when great violence has been applied to the symphysis. A solution of continuity sometimes occurs close to the last molar tooth (R.S., Fig. 19), whilst the coronoid process and condyle have also been broken, the former only as a result of severe direct force, *e.g.* a gunshot wound, the latter from either direct or indirect violence. Gunshot wounds of the lower jaw are often comminuted and associated with gross destruction of the soft tissues, and often with loss of considerable portions of bone.

The **Signs** of fracture are very evident if the lesion is situated anteriorly; but when behind the teeth, diagnosis may be much more difficult, apart from radiography. The usual variety is almost always compound, owing to the firm attachment of the muco-periosteum to the alveolar border. Laceration of the gums, the blood-stained saliva soon becoming fœtid, the irregularity in the line of the teeth, some of which have been knocked out or loosened,

and the easily elicited crepitus, all constitute a typical picture. There is often considerable pain, owing mainly to the tearing of the mucous membrane, but possibly due to implication of the inferior dental nerve. The main trunk, however, generally escapes, owing to the position of the fracture in front of the mental foramen, whilst in those behind there is but little displacement. Smart hæmorrhage sometimes occurs from laceration of the accompanying artery. The posterior fragment is usually raised and displaced outwards, whilst the anterior portion is depressed by the action of the hyoid muscles, and may overlap the other. In a bilateral fracture the loose central fragment is displaced downwards by the cauastive blow, and held in that position by the muscles, whilst the posterior fragments are drawn upwards and outwards by the temporal and masseter muscles. When situated *at the angle* or *in the vertical ramus,* there is such equal muscular support on the two sides that but little displacement results. When the fracture passes *through the neck of the condyle,* that process is drawn forwards and inwards by the external pterygoid, whilst the body of the bone is freely movable antero-posteriorly and displaced towards the fractured side. When the *coronoid process* is detached, it is dragged upwards by the temporal tendon, but no great displacement can occur, owing to the extensive attachment of the tendinous fibres.

Treatment.—Every effort must be made from the first to keep the mouth clean and free from infection by the frequent use of mild antiseptic lotions, especially before and after food. The co-operation of a dentist is always essential. Teeth that are merely loosened in their sockets may often be left, and will become refixed; but teeth that are quite loose, and all septic roots, should be removed, as also those sound teeth which obviously encroach on the line of fracture. The lesion is practically always septic, and the laying open of the deeper parts of the alveolus of any tooth involves it in the septic process, and converts it into a septic foreign body which necessarily must be removed. By this practice it is possible that a few teeth which might be saved will be sacrificed, but it is also certain that a great gain in cleanliness will more than compensate for this by increased rapidity of repair, and decreased likelihood of necrosis and other septic dangers.

The occurrence of serious septic osteitis is indicated by increasing pain and discharge, with inflammatory swelling below and outside the jaw; if need be, external incisions must be made to drain abscesses. Necrosed fragments of the bone ends are absorbed after a time or are separated as sequestra, and during the interval unremitting care as to cleansing the mouth must be maintained.

1. As a temporary measure, and indeed as a permanent appliance in simple cases without displacement of the fragments and where dental assistance is not to hand, all that is needed is an efficient four-tailed bandage. This is made by taking a piece of calico 4 inches wide and 1 yard in length, and splitting each end into two, leaving about 8 inches undivided, in the centre of which a small longitudinal cut is made for the insertion of the chin. The two lower

tails are then drawn up and tied over the vertex, whilst the two upper ends are secured behind the occiput, and then, to prevent slipping, are knotted to the ends of the former (Fig. 206). The bandage is maintained firmly in position for three weeks, the patient being fed through a tube passed between the teeth or through the gap behind the last molar, and all movement of the jaw prohibited. Union is usually effected in five weeks.

2. A more secure appliance consists in a light poroplastic or leather splint, carefully moulded to the jaw, or made in the shape indicated in Fig. 207, the upper portion, which should reach to the

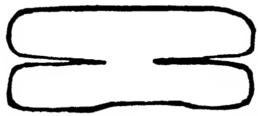


FIG. 207.—LEATHER SPLINT FOR LOWER JAW.

posterior border of the vertical ramus, being folded back over the lower portion, which is drawn up around the bone. It is lined with lint, and secured by bandages or tapes passed through holes, and tied as shown in Fig. 208.

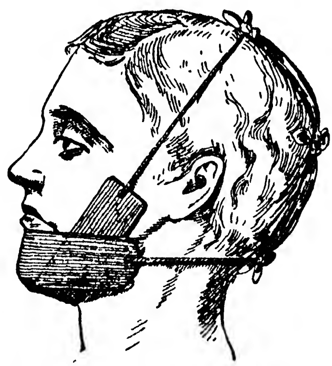


FIG. 208.—METHOD OF APPLICATION OF LEATHER JAW SPLINT.

3. In all cases where displacement of fragments is present, treatment must be undertaken in collaboration with a skilled dentist. Several different types of appliance to fix the fragments and steady the jaw are available.

The best appliance is *Gunning's interdental splint*, made of non-corrosive metal fitted over the crowns of all the teeth that are left of the lower jaw, only a bar or narrow bridge being present at the site of the fracture; this when fixed in position holds the fragments steadily. It is subsequently united to a similar splint fitted to the upper jaw, thereby securing complete rest to the mandible.

The mouth remains a little open, and a gap between the two splints in the middle line or corresponding to the fracture provides for feeding and irrigation. In the absence of sepsis union takes place readily in about five or six weeks.

A modification of this plan is available for cases where the jaw is edentulous or has no teeth suitable for fixation purposes. A vulcanite splint should then be provided, fitting over both alveolar ridges in the same way as an ordinary plate, and taking support from any teeth in the maxilla that may happen to be present. It is held in position by a four-tailed bandage, and is removable for cleansing purposes. Though an ideal result cannot be expected from such treatment, yet it will limit displacement and give comfort. Perhaps at a later date, when the parts are clean, it may be possible to fix the fragments by a metal or bone plate applied on the lower border of the bone through an external incision.

A less satisfactory method of treatment, but one that will suffice in many of the simpler cases, is the **Hammond wire splint.** It consists of a stout wire collar or framework (Fig 209), which encircles the whole series of teeth. It is accurately fitted by a dentist, firstly to a plaster cast, subsequently to the jaw itself, and is fixed by passing wires from one half to the other between the teeth.

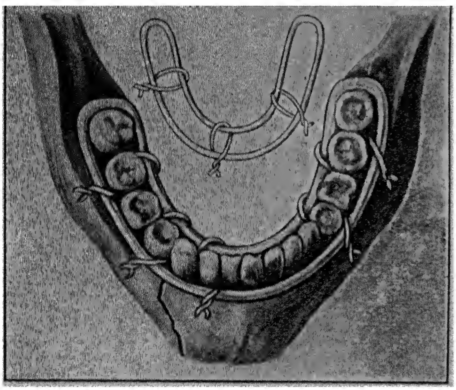


FIG. 209 —HAMMOND'S SPLINT FOR FRACTURE OF LOWER JAW.

The presence of a second fracture makes fixation much more difficult, but emphasizes the necessity for the assistance of a dentist, who alone can fit the intrabuccal splint necessary in such a case.

Slight loss of substance of the maxilla makes no difference in the principles of treatment. Every effort is made to clean the parts, and the fragments are brought into the best apposition possible by the interdental splint, and there allowed to unite, even if one half of the jaw is thereby displaced to one side for a time.

Gross loss of substance, such as has frequently occurred after gunshot wounds, can be made good by grafting, and the skill which has restored some of the unfortunate victims of these wounds to something like respectable appearance has been most remarkable and gratifying.

Ununited fractures of the mandible are not very uncommon. The patient must wait until all sepsis has disappeared and the wound in the mouth is healed, and then external operation holds

out a good chance of repair. The fracture may be wired, plated, or fixed by a bone graft.

Fracture of the Hyoid Bone is uncommon, arising usually from direct violence, such as a forcible grasp or the constriction of the neck in hanging. Either the body may be broken, or one of the cornua separated. The symptoms produced are: Pain on attempting to move the tongue, jaw, or neck; a husky voice, and deformity, which can sometimes be detected from without. Occasionally the mucous membrane is perforated, and bleeding into the pharynx may occur, whilst œdema of the glottis may supervene. The fragments should be approximated as well as possible by manipulation between one finger in the mouth and the hand outside, and the neck then fixed by a poroplastic collar.

Fracture of the Ribs may arise in two distinct ways: (1) By *direct violence*, as by blows or stabs, the fragments being driven inwards, and damage to the underlying pleura, lungs, liver, or diaphragm, being very likely to occur. Compound fractures due to penetrating wounds are not very common apart from military surgery; they are serious accidents as introducing the septic element, and possibly determining pulmonary collapse. (2) Much more frequently they are caused by *indirect violence*, as when the chest is compressed between a cart-wheel and the ground, or between a wall and the back of a waggon. The ends of the ribs are then approximated beyond the limits of natural elasticity, and they give way at the most convex part—*i.e.*, near the angle. The viscera may be contused, but less often than in the former class, although hæmothorax from rupture of the parietal pleura is not uncommon. As a rule more than one rib is broken, but the displacement is rarely marked, except in cases due to direct violence, where several ribs have been 'staved in.' The fifth to the eighth ribs are those usually injured, being more prominent and fixed at both ends; the first and second ribs are so well protected by the clavicle as to be seldom broken by direct injury, although great violence from above downwards to the outer end of the clavicle may lead to such an accident; the lower ribs often escape on account of their greater mobility. Elderly women and persons suffering from various mental diseases, such as general paralysis, are specially prone to this fracture.

The **Symptoms** are tolerably obvious, viz., a sensation of something snapping or giving way, a sharp localized catching pain at the site of the injury, increased on deep breathing and coughing, and possibly some local extravasation and swelling. Pain is elicited by a local examination, and also by conjoined pressure upon the sternum and spinal column, whilst the fracture may be evident on palpation, or crepitus detected when the patient coughs or on auscultation. When several ribs are driven in, a marked depression results, but if a single bone is broken in a fat individual, the diagnosis may be extremely obscure. The clinical history and treatment of the pulmonary or pleural complications, as also of penetrating wounds, associated with compound fractures, are discussed elsewhere.

Treatment.—The affected side should be firmly strapped with broad strips of adhesive plaster, so as to limit its movements. The strips, $1\frac{1}{2}$ to 2 inches wide, should extend beyond the middle line, both front and back, and are applied from below upwards, whilst the chest is in a state of forcible expiration, each strip overlapping the preceding one and crossing the direction of the ribs (Fig. 210). A firm woollen bandage should then be applied over all. If the ends of the bone are driven inwards, strapping can rarely be borne, as it tends still further to irritate or compress the lung. Under such circumstances all constriction of the chest must be avoided, the patient being confined to bed with a sandbag between the shoulders, and the arm bound to the side. When the lower ribs are broken, tight applications are generally contra-indicated, since the diaphragm is likely to be irritated, and troublesome hiccough may result. Ribs unite readily, but with a considerable amount of callus, owing to the mobility of the fragments.

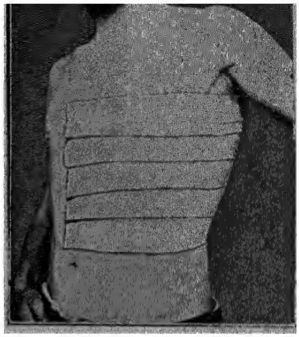


FIG. 210.—METHOD OF STRAPPING BROKEN RIBS.

Separation of a Costal Cartilage sometimes occurs, giving rise to similar symptoms and requiring the same treatment as a broken rib. Occasionally the cartilage itself may be fractured. In each case the resulting bond of union is osseous.

Fracture of the Sternum is almost always due to direct violence, but is occasionally caused by forcible flexion of the body, and is then generally associated with fracture of the spine. The line of fracture is usually transverse, the bone giving way either between the manubrium and gladiolus or a little below this level. The fragments may remain *in situ* or the upper portion be displaced backwards, the deformity in such cases being very evident, and great dyspnœa resulting. As a late effect, aneurism of the arch of the aorta may occur. **Treatment.**—The patient should be kept in bed with a pillow between the shoulders, and the chest strapped as for fractured ribs. If the patient cannot bear this portion, he should be allowed to sit up with the body leaning forwards. Reposition can sometimes be effected by manipulation and extension, but the possible co-existence of a fractured spine must not be overlooked.

Fractures of the Upper Extremity.

Fracture of the Clavicle.—No bone in the body, with the exception of the radius, is broken more frequently than the clavicle; this is due to its exposed position and its buttress-like action in keeping out the point of the shoulder, so that every shock to the arm is transmitted through it to the trunk. Although sometimes broken by direct

violence, fracture is usually due to force directed to the hand or shoulder, and hence is common in falls from horseback, and occurs frequently in jockeys, on the hunting-field or amongst recruits in mounted corps. It is more common in men than in women, and in children is often of a greenstick nature. The bone may yield in four different situations, viz.:

1. **At the Sternal End,** an unusual occurrence, due to direct or indirect violence. The displacement varies with the line of fracture; if transverse, it is slight; but if oblique, and this is most usual, the outer fragment is drawn downwards and forwards as in the next variety, though to a less degree.

2. **Through the Greater Convexity,** the commonest situation. The bone yields about its centre, or a little external to it, and the line of fracture is slightly oblique, running from before backwards, downwards, and inwards. The displacement is quite characteristic, and is present in any fracture situated between the rhomboid ligament on the inner side and the coraco-clavicular ligaments on the outer, being less marked, however, when the fracture is nearer the extremities than in the centre of this space. The patient gives a history of injury and severe pain, and supports the elbow with the other hand, the head being bent over to the affected side to relax the muscles of the neck; the arm is powerless. The point of the shoulder is less prominent than usual, being approximated to the middle line, and on a lower level than the other, whilst at the site of fracture the inner fragment projects. This deformity is accounted for by a displacement of the whole outer fragment downwards, forwards, and inwards (Fig 211), the outer end being, however, more displaced than the inner. This is mainly due to the weight of the arm acting upon the outer fragment when the buttress-like action of the bone is gone; muscular action has but little effect. The position of the inner fragment is probably but little altered, since it is held in place by the rhomboid ligament; the apparent projection of its outer end is mainly due to the depression of the outer fragment.

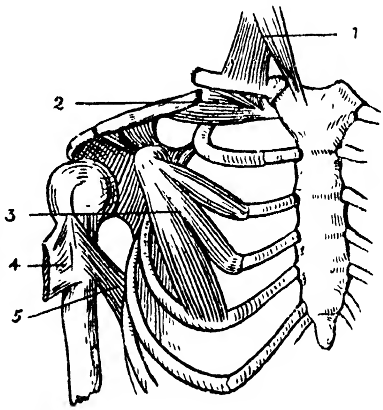


FIG. 211.—FRACTURE OF CLAVICLE THROUGH GREATER CONVEXITY.
1, Sterno-mastoid; 2, subclavius; 3, pectoralis minor; 4, pectoralis major; 5, latissimus dorsi.

3. **Between the Coraco-clavicular Ligaments,** usually arising from direct violence, and with but little displacement, owing to the tension of the ligaments and to the fact that the periosteum is not torn across. The signs of local trauma and crepitus are, however, present, though not very obvious.

4. **At the Acromial End,** external to the trapezoid ligament, and, again, generally produced by direct violence. The inner fragment retains its position unaltered, but the outer fragment is dragged down by the weight of the arm, and forwards by the action of the muscles, so that it sometimes lies at right angles to the rest of the bone.

Complications arise most frequently in cases produced by direct violence. The subclavian vein may be injured, or the brachial plexus; and even the dome of the pleura and the subjacent lung have been wounded. Gangrene of the arm has been caused by obstruction to the vessels. Great violence has resulted in fracture of the first rib. Excess of callus in repair not unfrequently leads to nerve pressure, which for its relief may require operation.

Treatment.—Where there is little or no displacement, all that is needed is to immobilize the arm in a sling and to keep the patient quiet. In a greenstick fracture, the deformity can be remedied by manipulation, and the arm bandaged to the side.

In fractures with displacement the deformity is as a rule easily remedied by drawing the point of the shoulder upwards and backwards, a knee between the scapulæ being used for counter-pressure and steadying of the patient. All that is required subsequently is to maintain this position for a time.

As an emergency measure the *three-handkerchief plan* can be employed. Two large handkerchiefs, folded double and rolled into bands, are placed vertically, one over each shoulder and under each axilla; each is lightly knotted behind, and the ends firmly tied to the opposite handkerchief across the middle line. By this means the point of the shoulder is kept outwards and backwards. The third handkerchief is used as a sling, the elbow being kept forwards and the hand placed over the sound clavicle.

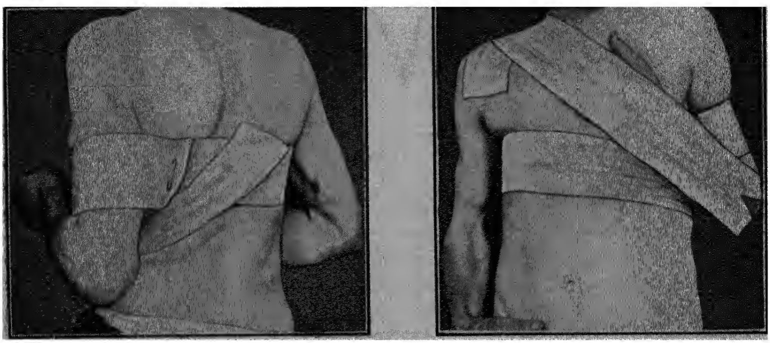
The simplest method of fixing the fracture in a young patient who is not too fat is by the use of a broad strip of *strapping* over the site of fracture so as to grip both fragments. If the right clavicle is broken, one end of the strapping is applied to the left side of the umbilicus and carried up over the chest wall to the clavicle, and thence over the shoulder and down the back to end on the left side of the body below the scapula. A folded pad of strapping several layers thick, and with the adhesive side out, may be moulded over the site of the fracture with advantage before the main strip is applied. Fixation thus being effected, the arm is supported in a sling for ten days or so, and then massage and movements of the shoulder are commenced. Some slight deformity may occur, but that is not of great importance, granting that the mobility of the arm is early restored. At Newmarket, where this plan has been largely used for jockeys, the patients are allowed to ride in about a fortnight.

In ladies, where even the slightest deformity is undesirable it

is better to confine them to bed for three weeks; the head is kept low without a pillow, and a sandbag placed between the scapulæ, the arm being bandaged to the side.

In children, one of the best plans of treatment is that suggested by Mr. Hey Groves. A straight splint is placed horizontally behind the shoulders, and a figure-of-8 bandage round the shoulders and splint, and, crossing in front, draws the shoulders back and remedies the displacement. This is kept in position for three or four weeks, and necessitates the child lying on its back at night.

Less satisfactory is the old-fashioned **Sayre's Method.** A long strip of adhesive plaster, $3\frac{1}{2}$ inches wide or less, is passed round the arm a little below the axilla as a loop, with the sticky side out, and then around the body with the adhesive side inwards, the arm being drawn well back, and the loop and end secured by stitches (Fig. 212). If this has been applied firmly, it may now be used as



Figs. 212 and 213.—Sayre's Method of Strapping for Fractured Clavicle

a fulcrum, so that as the elbow is drawn forwards the point of the shoulder is directed backwards and outwards, and thus the main deformity is overcome. Another strip of a similar width is applied over the elbow (a small hole being cut to receive the point of the olecranon), and by this means the elbow is raised and drawn forwards (Fig. 213), so that the hand can be placed on the opposite shoulder, and the desired position is thus maintained. Probably more than one strip of plaster will be needed in order to secure the arm, whilst an additional bandage is also useful. There is no need to maintain this position for more than ten to fourteen days, as massage and movements must then be employed to prevent stiffness; in the intervals of exercises or at night the arm may be bound to the side to avoid accidents, but daily movements must be practised

Ununited fractures are uncommon, but they occur and may

require fixation by operation. Vicious union is not rare, but seldom needs treatment.

Fractures of the Scapula.—1. The **Acromion Process** may be broken by direct violence applied to the point of the shoulder. The arm hangs powerless, supported by the other hand, and the shoulder is flattened. The irregularity of the bone can be readily detected, and crepitus can be elicited by raising the elbow and rotating the arm. Occasionally the tip alone is detached, and then the above signs will not be present. **Treatment** consists in raising the elbow, and bandaging the arm to the side.

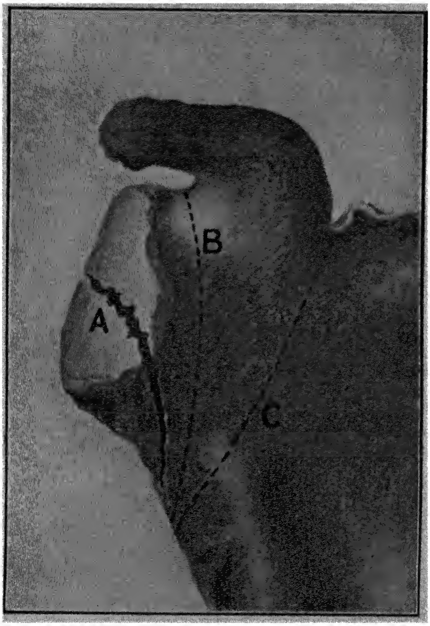


FIG. 214.—FRACTURES OF THE NECK OF THE SCAPULA.

A, Through the glenoid fossa; B, through the anatomical neck; C, through the surgical neck.

2. The **Coracoid Process** is rarely fractured, and then only by direct violence. There is but little displacement, on account of the powerful ligaments attached to it, and no treatment is needed except to raise the elbow by a sling and keep the arm to the side.

3. The **Body** of the scapula is broken as a result of considerable direct violence, which is often primarily received by the spine. There is but little displacement when the fracture is comminuted or transverse just below the spine. A longitudinal fracture may, however, result in the inner or vertebral fragment being drawn upwards

and outwards in front of the axillary portion by the serratus magnus and levator anguli scapulæ. The diagnosis is sometimes difficult owing to the presence of a large hæmatoma, but can usually be made by detecting crepitus on grasping the bone firmly, and moving one fragment on the other, or by radiography. **Treatment** consists in bandaging the arm to the side, and possibly applying strapping to support the fragments.

4. Fracture of the **Neck** is usually due to great violence directed to the shoulder, but is uncommon. A portion of the articular surface is broken off and displaced downwards in some few cases of dislocated shoulder (Fig. 214, A); or the fracture has been known to run through the anatomical neck (Fig. 214, B), either condition causing some flattening of the shoulder, slight lengthening of the arm, and displacement downwards of the head of the humerus, so that the appearance somewhat resembles that of a dislocation. **Treatment.**—The arm must be kept to the side and raised.

More commonly, however, the fracture involves the **Surgical Neck** (Fig. 214, C), extending from the suprascapular notch above to just below the origin of the triceps muscle, so that the detached fragment includes the coracoid process. Flattening of the shoulder results, with prominence of the acromion, lengthening of the arm as measured from the acromion to the external condyle, and crepitus on raising and rotating the limb. **Treatment.**—The bone is replaced by pressure in the axilla, if necessary under chloroform, and fixed by an axillary pad or a ∩-shaped leather splint, whilst the arm is kept to the side.

Fractures of the Upper End of the Humerus.—Of the **Anatomical Neck,** the so-called 'Intracapsular Fracture.' This is usually due to blows or falls on the shoulder, less commonly to indirect violence, and occurs more often in elderly people than in the young. The shoulder becomes greatly swollen from effusion of blood; pain on movement is severe, but crepitus may perhaps be felt on rotating the arm; there is usually about half an inch of shortening. In most cases the upper fragment is not totally detached, but remains connected with the rest of the bone by a few shreds of capsule, and thus necrosis is prevented; it is sometimes impacted into the lower fragment, and marked deformity of the head of the bone results, which can be detected occasionally by palpation from the axilla. If it is completely detached, the small upper fragment is often rotated on its own axis, and even dislocated into the axilla. Examination must be conducted with great care lest impaction be disturbed, or any remaining capsular attachments broken through; the use of radiography in all serious lesions of the shoulder renders such manipulation less necessary than formerly. Repair takes place mainly from the lower end, and, owing to the difficulty of apposing and immobilizing the fragments, a considerable mass of callus is usually formed. **Treatment.**—When there is but little displacement, nothing more is required than to raise the elbow and keep the arm to the side by a suitable bandage,

though a comfortable sense of support is given by placing a pad in the axilla. Massage is commenced early—about the fourth or fifth day—and passive movements a few days later. In the more serious cases a pad or ∩-shaped splint is placed in the axilla, and retained in position by a soft bandage or handkerchief passing over the top of the shoulder, and tied under the opposite axilla; this assists in raising the arm, which is also supported by an elbow-sling. Finally, a comfortable poroplastic or leather cap is fitted over the shoulder and buckled on. Union generally occurs in about six weeks, but often results in great stiffness, unless massage and manipulation are suitably employed; they must commence, however, a little later than in the simpler cases mentioned above. At first the splints, etc., are restored to position after the daily rubbing, but are gradually discarded, so that by the end of three weeks or so the arm is merely supported by a sling.

If dislocation or comminution of the small fragment has occurred, the surgeon may advisably raise the question of operation, with a view to removing the fragment entirely, if fixation by a bone-peg is impossible.

2. **Fracture of the Surgical Neck,** the 'Extracapsular Fracture' The bone yields in this case below the muscles attached to the tuberosities, but above or through the insertions into the bicipital groove and its margins of the latissimus dorsi, pectoralis major, and teres major. It results from violence applied directly below the point of the shoulder, or from falls on the hand or elbow, and is usually more or less transverse. The displacement of the upper fragment varies somewhat, and is often not very great, but in other cases it is abducted considerably. The lower fragment is drawn inwards by the muscles attached to the bicipital groove, and upwards by the deltoid, coraco-brachialis, biceps, and triceps (Fig. 215). The appearance of the patient is sufficiently characterstic; the head of the bone is still in the glenoid cavity, so that there is no loss of the fulness of the shoulder (Fig. 216, C), although there is a depression just below unless it is obliterated by the extensive hæmorrhagic effusion. The elbow is directed away from the side, and the axis of the lower fragment is upwards and inwards. Crepitus can be obtained by extending and rotating the arm, which is shortened an inch or more. This fracture is often very painful from pressure of the upper end of the lower fragment against the brachial nerves. If

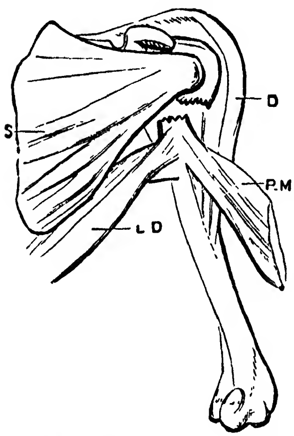


FIG. 215.—FRACTURE OF SURGICAL NECK OF HUMERUS.

S, Subscapularis; L.D., latissimus dorsi; D, deltoid; P.M., pectoralis major.

impaction occurs, the signs are much less evident, and, indeed, may be very equivocal; the lower fragment is usually driven into the upper, and only slight shortening or displacement may be present.

Complications.—The axillary vessels may be seriously damaged, or more commonly some of the nerves sustain injury, especially the circumflex, which winds round the neck of the bone close to the site of the fracture.

Treatment.—Correct alinement and immobilization of the fragments are absolutely necessary in this fracture. Reduction is easily effected except when the upper fragment is abducted, and then under an anæsthetic the lower segment must be gently carried outwards and abducted until the two fractured surfaces are in contact. It is sometimes possible to fit them together so perfectly as to permit the arm at once to be gently adducted to the side without displacement,

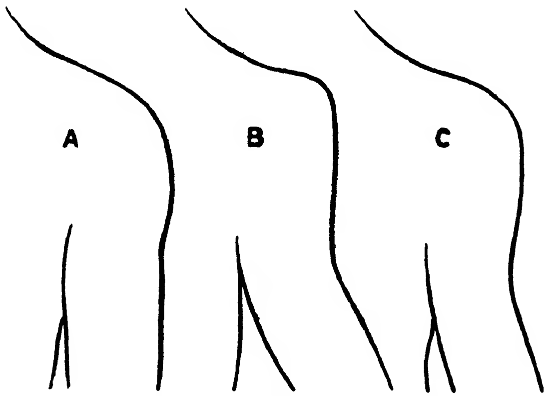


FIG. 216.—OUTLINES OF SHOULDER.

A, Normal shoulder; B, dislocation of the shoulder; C, fracture of surgical neck of humerus.

where it is secured by a shoulder-cap, the hand being supported by a sling. If the replacement is less satisfactory, a ∩-shaped leather or effective pad is placed in the axilla, and a shoulder-cap applied. Middeldorpf's triangle (Fig. 218) may be used with advantage in this fracture. When the fracture is oblique and the fragments overlap so that the deformity recurs after its reduction, the patient must be put to bed, and continuous traction made in an abducted position of the limb. An extension apparatus is applied to the arm from the elbow upwards, and a weight of from 5 to 10 pounds attached, the cord passing over a pulley at the side of the bed, or a Thomas's splint may be applied (Fig. 219). Counter-extension is made, if need be, by a sheet passed round the body. Gentle massage is employed from the first in order to assist absorption of the effused blood and to allay muscular spasm. At the end of three

weeks the patient is allowed up with a simple retentive apparatus, but daily massage and movements are maintained for some time. Firm union usually results in four and a half to six weeks, but with the formation of a good deal of callus.

Should the fracture be very oblique and the upper end of the lower fragment project much upwards and inwards, reduction may be very difficult and the pressure on nerves and vessels severe. In such cases open operation is often desirable. An incision is made along the anterior border of the deltoid, which is separated from the great pectoral, and thereby the anterior surface of the bone is exposed. This will often suffice to enable the ends of the fragments to be freed and brought into apposition, fixation being secured by wire, bone-peg, or a suitably curved narrow plate. If more exposure is needed, the incision is carried upwards and outwards, so as to enable the anterior portion of the deltoid to be divided about one inch below

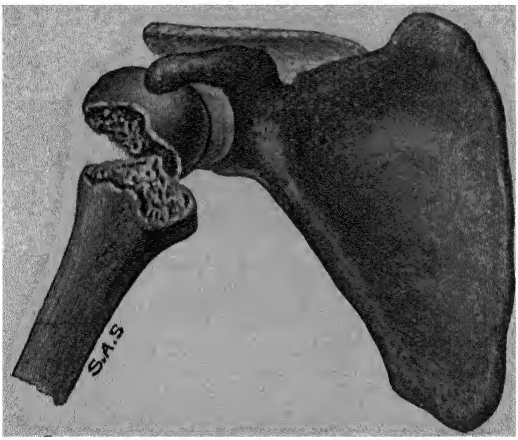


FIG. 217.—SEPARATION OF THE UPPER EPIPHYSIS OF THE HUMERUS.

the acromion process and turned downwards and backwards, thereby bringing into view the outer aspect of the head. The muscle is subsequently sutured carefully, and its function is not thereby impaired.

3. **Separation of the Upper Epiphysis** occurs up to the age of eighteen to twenty years, and involves the head and both the tuberosities (see Fig. 222). The upper end of the shaft is somewhat conical in shape, the apex of the cone fitting into a depression in the middle of the epiphysis (Fig. 217). The lesion usually follows the line of the cartilage; but the displacement is often incomplete, partly from the conical projection hitching against the inner edge of the epiphysis (a doubtful occurrence), but mainly from the persistence of a well-marked periosteal sleeve or bridge on the outer and posterior side. The shaft usually travels forwards, its upper end projecting so as to be felt or even seen beneath the skin an inch or more below the coracoid process; occasionally a well-marked inward displace-

ment is superadded, so that the condition somewhat resembles a subcoracoid dislocation. The presence of the head of the bone in the glenoid cavity should prevent this mistake, whilst the softness of the crepitus distinguishes it from a fracture.

Treatment.—It is most important to reduce this displacement, since otherwise interference with the growth of the limb is almost certain to ensue. This may be effected by traction upon the arm under an anæsthetic, assisted perhaps by slight rotary movements or abduction; but should these manœuvres not be successful, operation should be undertaken to restore the parts to their correct position by enlarging the hole in the periosteal sleeve. After reduction the limb is treated as for a fracture of the neck. Should union occur in the displaced position, considerable limitation of

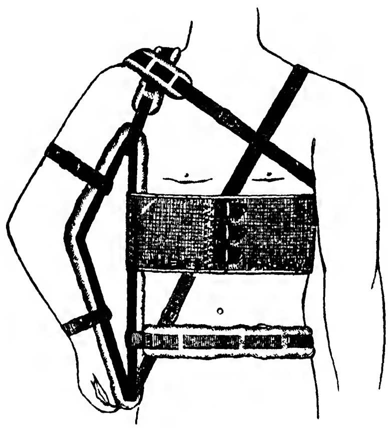


FIG. 218.—MIDDELDORPF'S TRIANGLE FOR FRACTURED HUMERUS.

movement results from the projecting edge of the diaphysis; this may be improved by cutting down and chiselling it away.

4. The **Great Tuberosity** is occasionally torn off as a result of direct or muscular violence, or as a complication of fracture through the neck. If the whole tuberosity is separated, there is marked deformity, resulting in a great increase in the breadth of the shoulder. The fragment is displaced upwards and backwards by the unopposed action of the spinati muscles, whilst the shaft of the humerus is drawn forwards and partially dislocated (or subluxated) by the subscapularis and other muscles. A distinct sulcus is felt between the two bony masses, and if they can be brought together, crepitus is obtained. **Treatment.**—There can be no question that when displacement has occurred, the most efficacious plan is to cut down on the fragment and fix it in position by wire, screw, or peg. This is best effected by cutting through and turning down the deltoid from above. Excellent results follow, if asepsis is maintained. Failing operative

treatment, the patient must be kept in bed, with the arm elevated and extended, supported by pillows—almost uncomfortable position—until union has occurred.

5. **Fracture of the Upper End of the Humerus combined with Dislocation** of the head of the bone is not a very common accident. The fracture is generally more or less oblique, and passes through the greater tuberosity or involves the surgical neck.

It is produced by severe direct violence, as by a person pitching with great force on the shoulder. The head of the bone is first forced into the axilla through a rent in the capsule, the tendons attached to the tuberosities being stretched or torn, and the fracture of the neck follows. Unless seen early, hæmorrhagic effusion makes diagnosis difficult and almost impossible, apart from stereoscopic radiography. If unreduced, the displaced head of the bone may remain loose, or union may occur with much deformity and the production of many adhesions, which may involve the vessels and nerves, and lead to serious after-trouble in the limb.

Treatment.—The reduction of the dislocation should always be attempted in the first place by manipulation and steady traction under complete anæsthesia. If successful, the fracture is treated in the usual way. More frequently reposition is not effected, and then operative measures should be undertaken without delay. The parts are laid open from the front, the head of the bone is replaced, and the fragments secured in accurate end-to-end apposition.

Fractures of the Shaft of the Humerus may arise from any form of violence, whether direct or indirect, and even from muscular violence, as, *e.g.*, in throwing a cricket-ball. The signs of the injury are very obvious, and most typical. The displacement depends largely on the position of the fracture. If it occurs *above* the insertion of the deltoid, but below or through that of the muscles inserted into or around the bicipital groove, the upper fragment is drawn inwards, and the lower upwards and outwards. If, however, it is *below* the deltoid, the upper fragment is drawn outwards, and the lower upwards and inwards. As the line of fracture approaches the elbow, the displacement tends to become more antero-posterior than lateral, owing to the change in shape of the bone. The most common complication is injury to the musculo-spiral nerve which winds round the shaft, and even if unwounded at the time of the accident, it is liable to be involved in the callus.

Treatment.—Reduction of the deformity is usually effected without much difficulty by traction on the forearm with the elbow bent to a right angle, and manipulation. In the simplest cases without displacement the arm is fixed to the chest wall, the most perfect means of immobilizing the limb. In all cases the forearm should be kept in full supination and directed a little forwards at an angle of about 25 degrees to the plane of the anterior chest wall, thereby avoiding internal rotation of the lower fragment.

In cases where the displacement is easily corrected and there is

no great tendency to recurrence, the simplest method of fixation is by means of an external plaster of Paris splint, made as described at p. 543 (method *c*), reaching from above the shoulder to below the elbow, and coming sufficiently round the arm to prevent lateral movements.

Fixation must be maintained for four weeks or more, but from early days full movements of the wrist and fingers are allowed, and

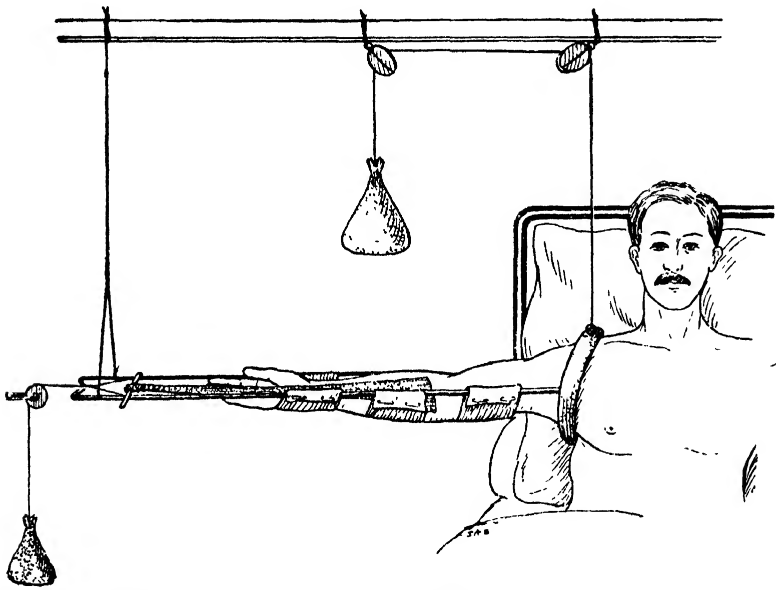


FIG. 219.—THOMAS'S SPLINT APPLIED FOR FRACTURE OF HUMERUS REQUIRING EXTENSION, ABDUCTION, AND SUSPENSION.

The hand is in full supination, and the ring of the splint kept in position by a counterpoising weight. Extension is effected by a weight, the end of which is attached to a transverse bar, sliding freely up and down the sides of the splint, and to this is secured the extension strapping or glued-on bandage, which reaches to the elbow. Of course a complete trough is required; only three flannel bands are depicted here, and short splints and bandages are omitted.

also of the radio-ulnar joints; flexion of the elbow with the arm still fixed and supported will follow a little later.

Where slight abduction is desirable, Middeldorpf's triangle (Fig. 218) or some modification thereof is extremely useful. It is carefully padded so that the angles and edges are protected. and applied so that its base is in contact with the body wall and its obtuse-angled apex fits to the elbow. It is fixed by a strap or bandage passed from the axillary angle over the same shoulder and under the opposite axilla, as also by a sheet or bandage round the trunk.

Pieces of Gooch splinting can be applied to the arm, thus completely immobilizing the humerus except for movements of rotation.

When the fracture is oblique or comminuted, prolonged extension is often necessary in order to maintain the fragments in good position, and the patient must be put to bed if abduction is also required. Weight extension over a pulley may be utilized, the fixative adhesive plaster taking its pull from the elbow to the fold of the axilla; short splints are applied to support the limb. Perhaps more satisfactory for this purpose is the short Thomas's splint, the well-padded ring of which takes its purchase from the axilla and chest wall (Fig. 219).

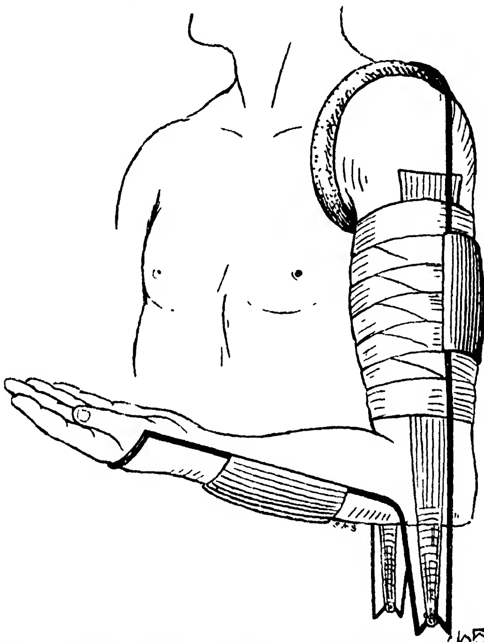


FIG. 220.—FLEXED-ARM SPLINT (ROBERT JONES) APPLIED FOR FRACTURED HUMERUS REQUIRING EXTENSION WITH THE ELBOW FLEXED.

Extension is effected by fixation to the splint, or by traction with a weight; the forearm is placed in full supination. The limb, of course, lies in a flannel trough, and if need be short arm splints are added to assist in correcting deformity. The splint with the arm is slung from a suitable overhead support, or otherwise kept from contact with the bed. Consolidation of the fracture, if closed, may be expected in three to five weeks, and then a simpler contrivance of the Middeldorpf type may be substituted. One objection to the Thomas splint for fractures of the arm is that the elbow is liable to become stiff. This can be prevented if at the end of seven to ten days passive movement of the elbow (including pronation and

supination) is undertaken once a day, the arm being, of course firmly supported. Another difficulty lies in the restoration of the carrying angle, which is liable to be lost unless the lower end of the humerus is drawn inwards slightly towards the inner bar of the splint.

In cases where prolonged extension is necessary, but abduction is not required, one of the many flexed-arm splints now available should be employed. Of these Sir R. Jones's modification of Thomas's splint (Fig. 220) is perhaps the best; the ends of the plaster extension-straps are tied to the cross-pieces that project below the elbow, or may be connected with a spring or elastic tractor, and short lateral splints may be added. The rules as to the position and movements of the forearm indicated above must also be followed.

Open fractures are treated on one of these two latter splints, perhaps for choice the Thomas, inasmuch as thereby easier approach can be secured to the wounds. Where extensive sepsis is present, and the treatment may have to be prolonged, stiffness of the elbow is very apt to follow unless early mobilization is undertaken. When the wounds are so placed as to hinder the application of strips of plaster, one of the other methods of extension suggested for the femur (p. 611) may have to be adopted, *e.g.*, by the use of a transfixion pin or by an extension calliper.

Operation for the fixation of a fracture of the shaft of the humerus should not often be needed, and, of course, is only undertaken for closed fractures or for open ones where asepsis of the wound is assured. The bone is best approached from the outer side of the biceps, between it and the deltoid, or triceps; the position of the musculo-spiral nerve must always be kept in mind. Wiring is usually difficult, and plating is the best means to adopt.

Ununited Fracture occurs not unfrequently in the humerus, and is probably due to the fact that the necessity for fixing and supporting the elbow-joint has not been appreciated, the forearm being allowed to hang loose on the false plea of tending to diminish the shortening. It also follows compound fractures where much bone has been removed or destroyed. More perfect fixation and improvement of the general health may cure it; otherwise operative treatment may have to be undertaken.

Fractures of the Lower End of the Humerus.—1. **Transverse Supracondyloid Fracture,** involving the shaft about 1 or 2 inches above the joint, is due either to a fall on the hand with the arm bent, when the lower fragment is usually displaced backwards, or much less commonly to a fall on or violence directed to the point of the elbow, when the displacement is either forwards or backwards. When the lower fragment is displaced backwards, it is also drawn up by the action of the triceps upon the olecranon, a certain amount of angular as well as vertical deformity being thus produced; when displaced forwards, apparent lengthening of the forearm results, with a loss of prominence of the olecranon. The former of these conditions is likely to be mistaken for a dislocation of both bones backwards at the elbow (*cf.* Fig. 221, A and B), but

may be recognized by the following facts: (*a*) The relative position of the bony points at the elbow is unimpaired; in a dislocation they are necessarily disturbed. (*b*) The length of the arm measured from the deltoid tubercle, which can be easily felt at the back of the acromion, to the outer condyle is diminished in a fracture, but remains unaltered in a dislocation. On the other hand, the length of the forearm, as measured from the external condyle to the styloid

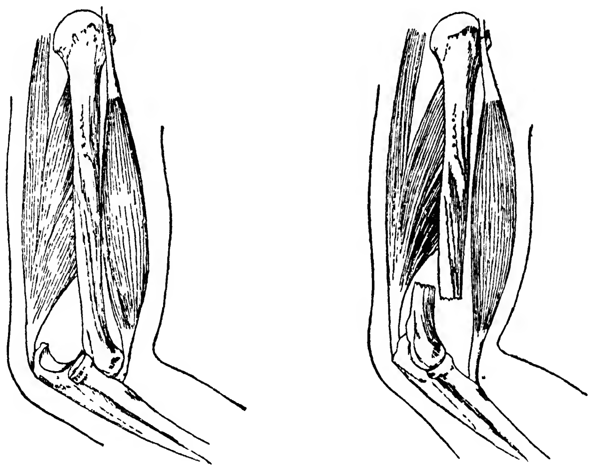


FIG. 221 —FRACTURE OF LOWER END OF HUMERUS (B) COMPARED WITH DISLOCATION OF RADIUS AND ULNA BACKWARDS AT ELBOW (A)

process of the radius, is shortened in a dislocation, but remains unaltered in a fracture. (*c*) The forward projection of the lower end of the upper fragment is felt above the crease of the joint, whilst in a dislocation it corresponds with it. (*d*) The deformity is easily reduced with crepitus, but readily reappears; in a dislocation the bones are replaced with difficulty, but after replacement they usually remain in position. Lateral deviation sometimes occurs, and the restoration of the normal 'carrying angle' must always be aimed at. It may be difficult and at times almost impossible to recognize this condition at once, owing to the amount of swelling and ecchymosis present, and therefore a radiographic examination of all serious elbow injuries is essential. Delay in order to permit of the reduction of the swelling is liable to be followed by serious consequences.

Treatment.—Reduction of the displacement is effected by downward traction of the elbow combined with flexion, and fixation in a good position is maintained by putting up the arm in a position of full flexion with the forearm completely supinated and the hand resting on the chest wall beneath the chin. It usually suffices to maintain this position by means of bandages or strapping without

splints, a layer of aseptic wool covered with dusting powder being placed between the adjacent surfaces of the arm and forearm; the elbow and arm are supported by a sling. In case of necessity, the best splint to use is a moulded gutter-shaped posterior splint reaching well above and below the elbow. In these fractures the elbow-joint is not as a rule involved, and therefore early movement is not essential.

There is some difference of opinion as to the character of the movements that should be permitted. Some claim that gentle massage followed by quiet passive movements is the best; the degree of movement is governed by the absence of pain; as the condition improves, a larger range of movement is available before pain is caused. The other school insists that massage does but little good, and that active movements limited again in range to those not causing pain are the best. Thus the hand, which at first was kept up just under the chin, is allowed to drop about 3 inches by relaxing the sling, and active movement within this limited range is permitted. Should pain be caused, the hand is replaced beneath the chin for another period of five to ten days. If no pain is caused, the hand is dropped for another inch or two, and the same process repeated until the forearm is at right angles to the arm, which probably occurs about four or five weeks after the accident. The sling is then discarded, and gravity will probably do the remaining work as regards extension, or at a little later date an anæsthetic may be given and the process completed. By this plan of treatment a very considerable range of movement can be secured, and that in its most useful position—viz., up to full flexion.

2. **T- or Y-shaped Fractures** usually occur as a result of direct injury. In a T-shaped fracture a longitudinal fissure extends into the joint through the centre of the lower fragment of a supracondyloid fracture; in a Y-shaped fracture the fissure starts at the articular line and bifurcates above so as to detach both condyles. Sometimes the fragments are not completely detached, and then, although there is much bruising and pain, crepitus is not obtainable; at other times the condyles are separated completely and will move on each other with crepitus, the elbow being increased in breadth. Displacement of the forearm laterally (usually outwards) often accompanies this lesion. Great swelling and ecchymosis are rapidly developed, and diagnosis apart from radiography is often difficult. If there is no separation of the fragments, **treatment** as for the transverse supracondyloid fracture suffices; but when they are completely detached, attempts to replace the fragments are usually unsuccessful, and it may be wise to operate in order to remove the blood and enable the fragments to be manipulated into position and fixed there by screws, wires, plates, or bolts, but not unless complete asepsis is assured.

3. Fracture of the **Condyles** (Fig. 223) usually results from direct injury, though the outer is sometimes broken by indirect violence,

such as a fall on the hand, since the laxity of the elbow-joint on this side allows considerable mobility between the radial head and the capitellum of the humerus. Fracture of the **external condyle** (Fig. 223, A) always involves the elbow-joint, and is more common than that of the inner. The line of fracture runs from the condyloid ridge downwards and inwards so as to separate the capitellum, or even to encroach upon the trochlear surface. The fragment is rotated forwards, and can be felt to move independently with crepitus, which may also be produced by rotation of the hand and radius. The accident is associated with much pain and ecchymosis. Fracture of the **internal condyle** may be intra- or extra-capsular. The *extra-articular* variety (Fig. 223, B) consists of a mere displacement of the tip of the condyle (or epicondyle), and in young people is probably a separation

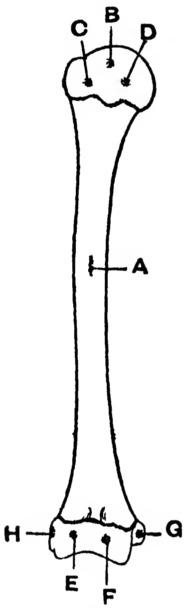


FIG. 222.—CENTRES OF OSSIFICATION OF THE HUMERUS.

A, Shaft appears at eighth week of intra-uterine life; B, centre for head in first year; C, centre for great tuberosity in third year; D, centre for lesser tuberosity in fifth year. B, C, and D fuse in sixth year to form one epiphysis, which joins the shaft at twentieth year.
E, Centre for capitellum in third year, F, centre for trochlear surface in eleventh year; G, centre for internal condyle in fifth year; H, centre for external condyle in twelfth year E, F, and H coalesce about the fourteenth year and join the shaft at the seventeenth year; G remains separate until the nineteenth year

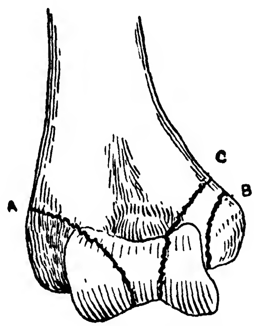


FIG. 223.—FRACTURES OF CONDYLES OF HUMERUS.

A, of external condyle.
B, of internal epicondyle
C, of internal condyle.

of the epiphysis, which remains distinct from the shaft till the age of eighteen or nineteen years (Fig. 222, G). The small fragment is drawn a little downwards by the muscles attached to it, and may be associated with injury of the ulnar nerve. The *intra-articular* form (Fig. 223, C) is the more common, and extends from the

condyloid ridge to the trochlear surface, implicating the coronoid and olecranon fossæ. The fragment is displaced a little upwards and backwards, the ulna usually accompanying it, so that on extending the elbow the olecranon appears unduly prominent, the lower end of the humerus projects anteriorly, and the forearm is slightly adducted (cubitus varus). The ulnar nerve may also be injured in this case.

Treatment.—Complete flexion of the elbow with traction downwards of the forearm in the direction of the axis of the limb will often enable the surgeon to manipulate the fragment into position. If the arm is then fixed in front of the chest with the elbow fully flexed, and the hand completely supinated and resting under the chin, repair in good position may be obtained. Movements follow along the lines indicated on p. 581; too vigorous massage and passive movements are harmful rather than beneficial.

A failure to secure complete reposition of the fragment will necessitate open operation, and its fixation by wire, bone-peg, or screw; but as already noted (p. 544), this is undesirable in children.

4. **Fractures in the Neighbourhood of the Lower Epiphysis of the Humerus** and involving its complete or partial separation are very common accidents in children. At birth and for some years afterwards the epiphysis consists of a single mass of cartilage (Fig. 222), including the two condyles as well as the articular surface, and these are all involved in any separation, together possibly with a fragment of the diaphysis (Fig. 224).

As, however, growth and ossification proceed, the shaft encroaches rapidly upon the inner portion of the epiphysis, so that the epiphyseal line becomes almost rectangular, the internal condyle being isolated from the rest of the epiphysis. As a result, this type of injury after the age of six or seven is placed at a somewhat higher level, and scarcely ever encroaches on the epiphyseal line. It is usually transverse and runs through the olecranon fossa. The displacement is generally backwards, often with some amount of lateral displacement or deviation. **Treatment.**—Reduction can usually be accomplished by flexion with some amount of traction. In young children, as in adults, it is best to avoid splints, and trust merely to keeping the limb in a state of full flexion, the hand being well supinated. Where there is much swelling from hæmorrhage, it may not be possible to gain complete flexion at once, but as the swelling subsides it can be gradually increased. In a few cases it may be desirable to make an incision through the periosteum on one or both sides of the bone, so as to allow the blood to escape and enable the lower fragment to be manipulated into position; but no attempt should be made to fix it by nails, screws, or wire. Flexion is maintained with the hand just below the chin for two or three weeks, or until all local tenderness has disappeared, and then the sling is relaxed so as to allow the hand to drop 3 inches, and the after-course is as for the transverse supracondyloid fractures.

Parents must, however, always be warned from the first that a perfect restoration of function cannot be guaranteed, as the fossæ at the lower end of the humerus are encroached on and are liable to be filled up with bone, and hence complete flexion or extension may be hindered. Some amount of deformity also may persist, and growth subsequently may be defective or irregular, giving rise to cubitus varus or valgus.

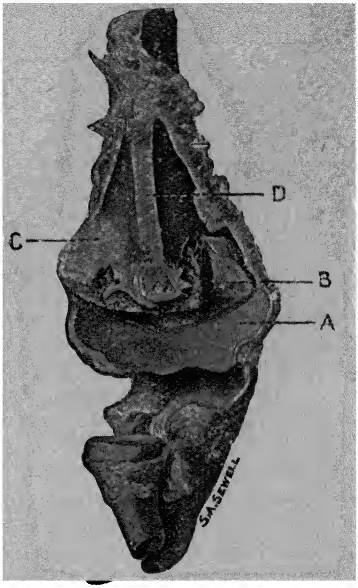


FIG. 224.—SEPARATION OF THE LOWER EPIPHYSIS OF THE HUMERUS IN AN INFANT UNDER THREE YEARS. (MUSEUM OF ROYAL COLLEGE OF SURGEONS.)

A, Epiphysis, including both condyles; B, small portion of the diaphysis detached with epiphysis; C, diaphysis, D, loose periosteal bridge.

Fractures of the Ulna.—1. The **Olecranon** is frequently broken by direct violence, the patient falling on the bent elbow, but occasionally by muscular action. The line of fracture usually runs through the base of the process of its attachment to the shaft, and is for the most part transverse. Should the tendinous and periosteal coverings of the bone remain intact, there is but little separation; but if the fracture is complete, the detached fragment is drawn up by the triceps and tilted backwards (R.S., Fig. 6), whilst the bones of the forearm are subluxated forwards. Great swelling in and around the joint comes on early; on examination, the detached fragment can be readily distinguished, and between it and the shaft a sulcus, which increases on flexing and diminishes on extending the forearm. If the fragments are not brought accurately into apposition, fibrous

union occurs, and although the new cicatricial tissue may stretch considerably, a useful elbow sometimes results; in some cases the fragment is drawn up and fixed to the humerus, and a false joint is developed below it. If, however, the fragments are brought in contact, bony union follows, though even then some impairment of function may result from the formation of adhesions. In all cases the ulnar nerve is exposed to injury, though it is rarely affected.

Treatment.—The arm must be kept fully extended on an anterior splint, and an effort made to bring the fragment into apposition with the end of the ulna by a pad and strapping. Gentle passive movements and massage are commenced at the end of ten days or a fortnight, but active movements should be deferred for another fortnight. When, however, the olecranon has been completely separated, the most satisfactory plan consists in laying the parts open, freeing the joint of blood-clot, removing shreds of tendon which may be placed between the fragments, and then wiring them together, the wire just extending down to the articular cartilage. A screw may be used in some cases (R.S., Fig. 7). Passive movements may usually be started in ten days, and active after a fortnight. A similar plan should be adopted in all clean open fractures, and in those where loose fibrous union has occurred with a resulting weak and relaxed elbow; in the latter instance the new fibrous tissue must be entirely dissected away and the bony surfaces freshened.

2. The **Coronoid Process** is so deeply placed and so well protected that fractures must necessarily be very uncommon, except as an accompaniment of dislocation of the ulna backwards. The signs relied on in making a diagnosis are that reduction of the dislocation is easier than usual and associated with crepitus, and that the deformity is likely to recur. The **Treatment** consists in apposing the bony surfaces, if possible, by complete flexion of the forearm.

3. The **Shaft of the Ulna** is often fractured by itself as a result of direct violence, to which its exposed position renders it peculiarly liable. Fracture also occurs as a complication of several of the forms of dislocation of the radius alone. The superficial position of the posterior border renders examination of the bone easy; if displacement or a breach of substance occurs, it is readily detected, but when merely a fissure exists, it is not so easy to make out. The constant pain referred to one spot, the slight mobility, and possibly crepitus, indicate the character of the lesion. No longitudinal displacement can occur if the radius remains intact, and under such circumstances the only deformity consists in a slight drawing forwards of the upper fragment by the brachialis anticus, whilst the lower fragment is approximated to the radius by the pronator quadratus. **Treatment.**—The arm is placed midway between pronation and supination, the deformity corrected, and the limb kept at rest between anterior and posterior splints, or in plaster of Paris.

4. The **Styloid Process** may be detached by direct violence, or as a complication of fracture of the lower end of the radius. The displacement may be considerable and very evident, being governed by the direction of the violence. **Treatment** consists in replacing the fragment by manipulation, and fixing it by adhesive plaster; an anterior splint is applied with the hand adducted. Firm fibrous union usually results.

Fractures of the Radius.—1. The **Head of the Radius** may be broken alone, but this accident is often associated with other injuries to the elbow, as, for instance, fracture of the outer condyle or some form of dislocation. The line of fracture may be transverse or vertical, or comminution may occur; the displacement is slight if the orbicular ligament remains intact. In complete separation the head is immovable, and crepitus is produced when the arm is rotated; bony union usually follows, with more or less impairment of function, but sometimes the head, or a portion of it, remains detached as a loose body; in the latter case the small fragment may get between the articular ends from time to time and lock the joint. **Treatment.**—Radiography will indicate the exact nature of the injury, and as a rule removal of the loose fragment and of the remainder of the head, if it be small, is the best plan to adopt. The incision is of course a posterior one. The limb is subsequently kept at rest in full supination, and early passive movement instituted. Excision of the head may also be required in old-standing cases for limitation of movement, due to excessive formation of callus.

2. The **Neck,** *i.e.* the portion between the orbicular ligament and the biceps tuberosity, is occasionally broken. The lower fragment is drawn upwards and forwards by the biceps, causing a bony projection on the front of the elbow, especially evident on attempting to flex the joint, whilst the forearm is pronated with loss of the power of rotation, and the head of the bone does not accompany the shaft on rotating it passively. **Treatment.**—The arm is fully flexed to relax the biceps and completely supinated. Movement, active or passive, should not be commenced too early, as the lesion is extra-articular, and the biceps may produce permanent deformity if allowed to act upon unconsolidated callus.

3. The **Shaft** of the radius is not unfrequently broken by direct violence or more rarely by falls on the palm; the latter accident, however, rarely causes fracture except at the lower end. Many types of *chauffeur's fracture* of this bone have been described, but most often it involves the lower end of the radius, about 2 to 3 inches above the wrist, and results from a jerk backwards of the starting handle of the car due to premature ignition. Well-marked anterior displacement is usually present.

There is usually little difficulty in diagnosing a fractured radius; the chief signs are localized pain and loss of power of active rotation, whilst passive rotary movements are accompanied by crepitus, the head of the bone and upper fragment remaining immobile below the outer condyle, unless impaction is present. The *displacement* is

somewhat characteristic. If the fracture is situated *above the insertion of the pronator teres*, the upper fragment is flexed and fully supinated by the action of the biceps and supinator brevis, whilst the lower fragment is drawn towards the ulna and fully pronated by the unopposed action of the two pronator muscles.

When the fracture is placed *below the insertion of the pronator teres*, the upper fragment is drawn forwards by the action of the biceps, and inwards by the pronator, assuming a position midway between pronation and supination; the lower fragment may be slightly approximated to the ulna by the direct action of the pronator quadratus; the hand is fully pronated looking downwards. Union to the ulna by callus thrown across the interosseous space has been known to occur.

Treatment.—*All fractures of the shaft of the radius* (with the exception of Colles's) *must be treated in complete supination,* not only because thereby can coaptation of the fragments be alone satisfactorily effected, but also with a view to avoid union in the position of complete or partial pronation. The hand must be kept 'palm up' in the position in which a gift is accepted, if a useful functional result is to follow. The adoption of this position with flexion of the elbow should enable the practitioner to bring the fragments into correct alinement without difficulty. The position in a closed fracture is maintained by the use of a posterior gutter splint; a short anterior curved splint over the front of the forearm will assist in preventing anterior displacement of the bone ends.

In open fractures a straight-arm Thomas's splint should be employed, or a Robert Jones's splint if flexion of the elbow is necessary.

4. The **Lower End of the Radius** is broken with extreme frequency, constituting what is known as **Colles's Fracture.** This injury occurs most commonly in women of advanced years, although it may happen at any age or to either sex. It is almost invariably due to falls upon the outstretched palm, when the hand is completely pronated and extended. The line of fracture is placed about 1 inch from the wrist, though rather under than over this. It is usually transverse from side to side, but is oblique in an antero-posterior direction, sloping from above downwards and forwards, so that the fracture is nearer the wrist-joint in front than it is behind (R.S., Figs. 10 and 11).

The *displacement* is somewhat complicated. (*a*) The lower fragment is carried backwards and a little upwards, owing to the direction of the violence, viz., a fall on the outstretched hand, the radius being compressed between the ground and the weight of the body, and yielding at what is evidently a weak spot; this deformity is maintained by the radial extensor muscles of the wrist, and often by impaction of the fragments. (*b*) From the fact that the main violence is received on the thenar eminence, the outer side of the lower fragment is displaced more than the inner, which remains fixed to the ulna by the strong inferior radio-ulnar ligaments. This posi-

tion is in part kept up by the extensor of the thumb and the supinator longus, but mainly by impaction of the fragments. The hand and carpus always follow the lower fragments, and hence the former is abducted, causing the styloid process of the ulna to become unduly prominent, and lower than that of the radius, whereas it is normally placed on a slightly higher level. In bad cases the styloid process of the ulna is actually torn off, or the internal lateral ligament ruptured, allowing displacement outwards of the whole hand. (*c*) The lower fragment is also rotated around a transverse axis, so

FIG. 225.—COLLES'S FRACTURE LATERAL VIEW.

that the lower articular surface looks backwards as well as downwards, a displacement due to the fact that in falling the force is directed, through the carpus, more to the posterior than to the anterior aspect of the bone. (*d*) The upper fragment is pronated and approximated to the ulna by the pronator quadratus muscle. The *deformity* produced by the fracture is therefore very characteristic. The hand is in a position of radial abduction, and usually pronated, with the fingers somewhat flexed (dinner-fork deformity). Three abnormal osseous projections are present: (i.) The styloid process or head of the ulna is very marked, owing to the radial

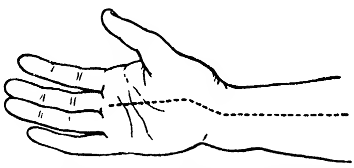


FIG. 226.—COLLES'S FRACTURE: PALMAR VIEW.

abduction of the hand (Fig. 226); (ii.) on the back of the wrist is a prominence which terminates abruptly above, caused by the projection of the lower fragment (Fig. 225); and (iii.) corresponding to this dorsal projection there is a well-marked depression on the palmar surface, and above it a less sharply defined swelling, which gradually shelves into the forearm, due to the upper fragment. Pronation and supination are lost, and, as a rule, there is neither crepitus nor preternatural mobility, owing to impaction of the fragments. An important diagnostic point is the relative position

of the two styloid processes; normally, that of the radius is below that of the ulna, but in cases of fracture it is on a level with or above it.

The fracture is commonly impacted, the upper fragment being firmly driven into the cancellous tissue of the lower end; excess of violence may, however, disimpact, but often at the expense of comminution of the lower fragment. Union is effected without difficulty, but the patient should always be warned at an early date that some deformity may persist about the wrist, as well as some impairment in the subsequent mobility of the fingers and hand, owing to adhesions in the joint or tendon sheaths.

Treatment.—It is most important completely to reduce the deformity, and to this end extension and manipulation are both needed. The patient, if not under an anæsthetic, should be seated on a chair, and the surgeon, standing in front, should grasp the hand firmly, using the right hand for fractures on the right side, and the left for those on that side. Counter-extension is made from the flexed elbow, and the hand is then forcibly extended and adducted; disimpaction is thus brought about, and a little manipulation enables the fragments to be moulded into position. If this proceeding should fail to secure reduction, the surgeon must gain a firmer grasp of the parts by taking the wrist between the two hands, the thenar eminence of one against the projecting lower end of the shaft; that of the other against the projecting lower fragment. 'A firm grip with a slight traction and twist of the wrist completely reduces the deformity; it requires knack rather than strength' (R. Jones). The completion of the reduction is recognized by the restoration of the concavity in the anterior surface of the lower end of the bone, and by that of the relative positions of the styloid processes. In old people, however, where impaction is present, it may be wiser to leave things alone, and not to attempt disimpaction or correction of the deformity.

When once the deformity has been corrected, there is but little tendency for it to reappear, and therefore the use of elaborate retentive apparatus or splints is quite unnecessary in the majority of cases. (1) Perhaps the simplest and most efficacious is a piece of Gooch splint, shaped so as to cover the radius front and back as far as the middle line of the arm, and extending nearly from the elbow to the front and back of the knuckles of the index and middle fingers; its lower end is hollowed out in a horseshoe manner, so as not to reach beyond the end of the metacarpal bone of the thumb. This is well padded and firmly bandaged on; it grasps the radius and steadies the hand in a position of adduction, without in any way interfering with the movements of the fingers. (2) *Carr's splint* (Fig. 227) may be used in some of the more severe cases, especially when the ulnar styloid process has been fractured. It consists of two portions fitting the front and back of the radial side of the forearm; to the palmar portion is attached an oblique rod to be grasped by the fingers, and thus the hand and wrist

are maintained in a position of adduction, whilst the fingers can be freely moved. (3) *Gordon's splint* is another excellent contrivance occasionally useful, which consists of two pieces. The palmar portion has a curved projection on its radial side, to correspond to the site of the fracture and to the concavity of the lower end of the radius; on the ulnar side it is prolonged, so as to fit the ulnar border of the hand. The dorsal splint is slightly curved at the lower end, so as to apply itself comfortably to the wrist when in a position of flexion.

Union is usually firm enough in ten to fourteen days to permit the removal of the splints, the arm being kept in a leather or poroplastic support for some time longer. Gentle massage and passive movements should be employed, and the fingers left free and exercised after the first three or four days.

A fracture of the lower end of the radius, known as *Smith's fracture*, is occasionally met with, in which the displacement of the fragment is exactly the reverse to that seen in Colles's fracture.

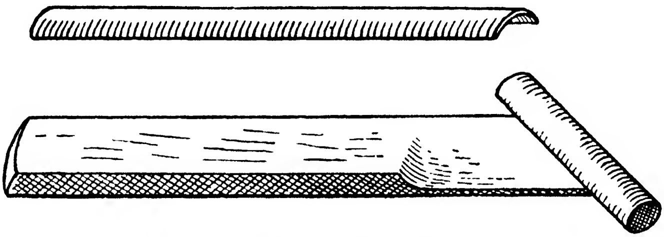


FIG. 227 —CARR'S SPLINT FOR COLLES'S FRACTURE OF LEFT HAND.

viz., the lower end of the radial shaft projects posteriorly, whilst the lower fragment is displaced anteriorly. **Treatment** is conducted as for a Colles's fracture.

5. **Separation of the Lower Epiphysis** of the radius occurs in young people under twenty, and when it is displaced backwards, simulates somewhat closely a Colles's fracture. The lower end of the diaphysis projects anteriorly to a much greater extent, and, indeed, may protrude through the skin of the wrist, and then grave septic complications may supervene, leading to more or less extensive necrosis; indeed, the author has removed the whole shaft of the radius as a sequestrum due to acute osteomyelitis caused in this way. The lower end of the ulna may be involved in the accident, either the epiphysis being separated, or the shaft broken a little above. This condition may be mistaken for a backward dislocation of the wrist, but a diagnosis can be readily made by observing the relative position of the styloid processes to the carpal bones. Lateral displacement occurs in some cases. **Treatment** is practically the same as for Colles's fracture.

Should arrest of growth result, the hand retains its connection with the stunted radius, but the ulna continues to grow downwards

and its lower end projects on the inner and posterior aspect of the carpus, which is pushed *en bloc* towards the radial side, but without any marked abduction (Madelung's deformity). (R.S., Fig. 12.)

Fracture of both Bones of the Forearm may result from direct violence or falls on the palm. Any part of the bones may yield, but the middle and lower thirds are most frequently affected. When due to direct violence, both bones may be broken at the same level; but if due to a fall on the palm, the ulna usually gives way at a higher level than the radius. The line of fracture may be transverse or oblique, and the displacement varies both with this and with the force employed. The upper fragments are usually drawn together and pronated, whilst the lower end of the radius is drawn up by the supinator longus. In young people a not uncommon result of falls in the football-field or at the skating-rink is a complete fracture of the lower third of the radius, and a green-stick fracture of the ulna (R.S., Fig. 4). The upper fragment of the radius is displaced forwards in front of the pronator quadratus, which prevents its replacement even by traction under an anæsthetic. The diagnosis is usually simple, since there is, as a rule, obvious deformity.

Treatment.—It is most important in this fracture to restore the bones completely to their correct alinement, since failure to do so almost always involves serious impairment of function, both as regards rotation and the movements of the fingers. In a few cases cross-union follows, but this is not common when reasonable precautions have been taken. The rule of treating all fractures of the radius with the hand in full supination holds good, although it must be admitted that it is not so essential in fractures of the lower third, and occasionally when complications exist which might cause ankylosis of the radio-ulnar joints it has to be laid aside, and a position midway between pronation and supination adopted.

Correction of the deformity and re-alinement of the fragments can generally be effected by traction under an anæsthetic. An assistant grasps the elbow bent to a right angle and makes counter-traction from above; the surgeon grasps the wrist with one hand and makes extension, and with the other hand he manipulates the fragments into position. It is obvious that the sooner this is undertaken after the accident, the better the chance of getting effective reduction.

Fixation of the parts is secured by the use of a padded posterior right-angled wooden or metal gutter splint reaching from the axilla above to beyond the knuckles; with this a short anterior wooden splint is employed, reaching from just below the fold of the elbow to the wrist; *it must not press on the tissues of the arm.* These are fixed by strapping and then bandaged securely, but not too tightly. A similar result can be obtained by the use of plaster, a casing made along the lines indicated on p. 543 being fitted to the back of the arm and forearm in the first case, and afterwards a casing for the front of the forearm; this can easily be removed and replaced for massage, etc.

Should closed reduction by traction fail, operation is essential,

and it has been found in practice that quite a considerable number of patients have to submit to this in order to secure a good result. Of course, the most emphatic precautions must be taken as regards asepsis to render this justifiable. The ulna is easily exposed by an incision along its posterior border; but it is less easy to reach the radius without damaging the muscles. The incision should pass behind the supinator longus, between it and the radial extensor tendons; the origin of the extensor muscles of the thumb may have to be disturbed, but with care no permanent damage follows; in the upper part the position of the posterior interosseous nerve must be remembered. The ends of the bones are freed and brought into position, and fixed by suitable means; a plate to the radius is sometimes needed, but the ulna may usually do without it.

It is only when treatment of this type is ineffective or impracticable that prolonged extension is required, and then it may be effected by the use of a Thomas's arm splint (Fig. 219). A gauze sling is glued to the forearm back and front, and from the free loop beyond the finger-tips extension can be made if need be by weight and pulley. The limb may be kept flexed or straight. This plan is of most use in open fractures, and, indeed, in gunshot wounds it may be the only practicable procedure; but it is very likely to be followed by stiffness or fixity of the elbow and of the fingers unless careful preventive measures are taken. It necessitates the patient being kept in bed, and this alone is a hindrance in civilian work. In some cases it may suffice to make extension by means of a glove glued to the hand, as in Fig. 228.

Fractures of the Carpus.—These may result from direct violence in the nature of a severe crush, and then several of the bones may be involved, and the lesion may be compound. The ordinary treatment of such a condition must be followed, and the part kept at rest on a palmar splint.

Radiography has demonstrated that many 'sprains of the wrist' from indirect violence are in reality associated with fracture of a carpal bone, and of these a transverse fracture through the waist of the scaphoid is perhaps the most common. As a rule, rest in the dorsiflexed position of the hand and subsequent massage are alone required; but occasionally movement is impaired by a displaced fragment, or painful weakness follows from non-union, and then removal of the fragment or of the bone is necessary.

Fractures of the Metacarpal Bones and Phalanges (R.S., Fig. 14) are not uncommon, particularly in the third and fourth fingers, being due to direct violence, and hence often transverse. There is generally but little displacement, though occasionally the fragments may overlap, whilst a certain amount of localized swelling and tenderness is always noted.

Treatment of a fractured metacarpal with little or no displacement is merely immobilization of the hand on a cock-up splint for two weeks or so; but if the fragments overlap and shortening of the finger is threatened, prolonged extension is required. This is easily effected where one metacarpal alone is involved by applying a metal palmar

plate, to which is fixed a solid bar reaching below and beyond the finger. Adhesive plaster is fixed to the finger front and back by encircling strips, or the finger of a glove is glued on, and tape carried through the tip. These bands tied firmly to the rounded termination of the projecting bar provide the needful extending force. If several metacarpals are broken, it is wiser to apply to the forearm a skeleton aluminium splint which terminates in a circular metal frame projecting well beyond the finger-tips to which the several extension strips can be firmly tied (Fig. 229). Operation for these conditions

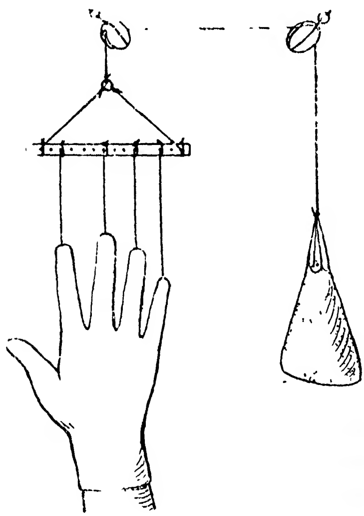


FIG. 228.—GLOVE EXTENSION FOR FRACTURES OF FOREARM.

Instead of threading tapes through the finger-tips, some surgeons insert a button in the finger-tip before putting on the glove to act as a spreader; a cord passed through the centre of the button and knotted acts as the extending agent.

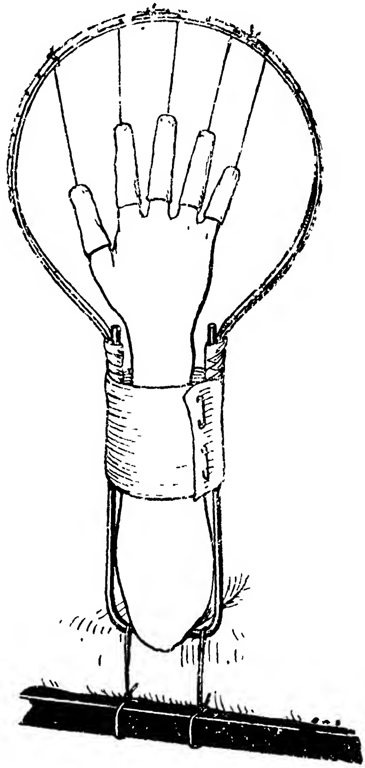


FIG 229.—TREATMENT OF FRACTURED FOREARM OR METACARPALS BY EXTENSION.

This appliance could also be utilized for some less serious cases of fracture of the forearm needing extension where the patient cannot remain in bed. The lateral bars must then be carried up either side of the arm and join together behind the elbow, which is fixed to them so as to give support for counter-extension.

is undesirable, as it almost certainly interferes with the tendons, and their subsequent mobility is jeopardized.

Bennett, of Dublin, has described an interesting fracture of the first metacarpal (*stave of the thumb*), which is due to indirect violence,

and not very rare. The line of fracture is oblique (R.S., Fig. 13), separating the anterior portion of the base, which remains *in situ*, from the rest of the shaft, which is drawn upwards and backwards by the long extensor tendons, so as to lie behind the trapezium. Should the displacement be overlooked, the bone unites in this position, and the deformity, which persists, determines weakness and disability of the thumb. **Treatment.**—Reduction is usually effected with ease by traction, and prolonged extension as described above is necessary.

Fractures of the Pelvis.

Fractures of the pelvic bones are almost always the result of direct injury, such as falls, blows, gunshot wounds, or crushes in railway, carriage, or motor accidents. For convenience they may be described under the following headings:

1. **Fractures of the False Pelvis.**—A portion of the crista ilii may be broken off, or the anterior superior spine separated, or merely a fissure in the bone produced. The displacement is rarely great, although a portion of the crest may be drawn down by the glutei muscles, or the anterior superior spine displaced by the sartorius. Considerable pain is always present, especially on any vigorous respiratory movements, but crepitus is rarely to be detected. Union occurs readily if the patient is kept quiet in bed with the shoulders raised, and the legs supported to relax the muscles. A flannel bandage round the pelvis gives comfort and support.

Septic penetrating wounds, such as follow gunshot injuries, are liable to result in a subacute spreading osteomyelitis which is most troublesome. Not unfrequently an abscess forms on the inner aspect of the bone, communicating with the exterior by the narrow passage in the bone made by the penetrating body. Pus may track up and down the iliacus muscle, and the cavity fills and empties itself through the wound from time to time. The only treatment that is effective consists in opening up the external wound and enlarging the aperture in the bone so as to secure effective drainage; or it may be necessary to open up the iliac fossa from the front, burrowing through and under the iliacus muscle.

2. **Fracture of the True Pelvis** is a much more serious accident. The line of fracture in front usually runs into the obturator foramen, and involves both the horizontal and descending rami of the pubes or the ascending ramus of the ischium (Fig. 230). This is frequently conjoined behind with a fracture in the neighbourhood of the sacro-iliac synchondrosis either on the same or opposite side, but more frequently the latter; whilst a double fracture, front and back, may also occur at these, the weakest, points. The cause of the posterior fracture is that, when the pelvic ring has yielded anteriorly from the violence, the continued strain, whether directed from the front or from the sides, necessarily falls on the part where the ilium is most closely connected with the sacrum, and the bones then give way rather than the unyielding and powerful sacro-iliac ligaments.

Probably the fracture involves the lateral mass of the sacrum rather more frequently than the ilium. The **Symptoms** are those of severe shock and pain in and around the pelvis, especially on movements of the legs or on coughing. There may be local ecchymosis and tenderness over the pubic ramus, as also deeply in the iliac fossa, and the patient either cannot stand, or feels as if he were falling to pieces on attempting to do so. Usually there is but little deformity, although occasionally displacement backwards of the innominate bone is visible, and depression of the pubic symphysis or of the ischial or pubic rami may be palpable. Crepitus may be elicited on grasping the iliac bones, and moving them one on the other; but such a method of investigation must be indulged in very sparingly.

The chief dangers from a fractured pelvis arise from the presence of co-existent *visceral lesions*, especially to the urethra, bladder, or rectum. The membranous portion of the urethra is torn by the displacement of the pubic symphysis, and this is indicated by escape of blood from the meatus Every effort must be made to prevent extravasation of urine, and *the patient warned against passing water, however urgent the desire*. Rupture of the bladder results in pelvic or intraperitoneal extravasation, according to the site of the lesion. The rectum may be punctured by the displaced pubic rami, and on examination the ends of the bones may be felt in the rectum. The vagina and the pelvic vessels and nerves are less frequently injured.

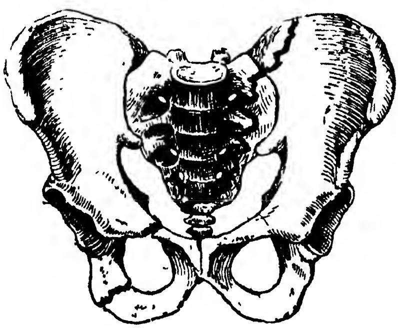


FIG. 230.—FRACTURE OF THE PELVIS.

The fracture runs through the sacrum on the left side, and through the horizontal and descending rami of the pubes of the opposite side.

Treatment.—The patient should be moved with the greatest care, both on account of the shock, and also for fear of producing or increasing visceral complications. He is put to bed on a divided mattress (Fig. 250) with fracture-boards beneath it, and kept quiet until the shock has in measure passed off. A more complete examination is then made, if need be under an anæsthetic, and complications dealt with. It is rarely desirable to attempt replacement of the fragments, which gradually return to a more or less normal position. The pubes, however, may be pushed forwards by a finger in the rectum or vagina. A many-tailed bandage or broad binder is advisable to steady the parts, and the patient's knees must be tied together; he should, of course, be rolled over on the sound side in order to wash the back.

The visceral complications demand suitable treatment, and especially the urethra, which must be examined in all cases and the

water drawn off by a sterilized catheter. If the urethra is torn, it may be possible to pass a catheter and tie it in; but failing this, a perineal incision must be made in order to prevent urinary infiltration. If the pubic rami are also felt projecting into the rectum, it may be advisable to prolong the perineal incision backwards so as to lay open that viscus freely, thereby allowing free exit to fæces and discharge, and permitting of more satisfactory cleansing.

Apart from complications, union may be expected in about six weeks, but the patient should be kept in bed for at least eight, and even then only allowed to get about on crutches, wearing a padded belt. Late complications in the form of abscesses connected with necrosis of the pubic rami or pelvic extravasation may, of course, arise, and prove fatal or delay convalescence.

3. **Fracture of the Acetabulum** is of two types: (1) The posterior lip is broken off by the head of the femur, which is dislocated backwards by the same accident. Reduction is affected easily and with crepitus, but the displacement usually recurs, and to prevent it prolonged and effective extension is required with the leg abducted. (2) A heavy fall on the trochanter may cause (*a*) a simple fissure extending into or across the cavity, or (*b*) a starred fracture, possibly resolving the cavity into its three constituent elements, or (*c*) it may even drive the head of the bone into the pelvis (*central dislocation of the femur*. A mere fissure of the acetabulum produces but few symptoms beyond a little pain and impairment of movement; but if the head of the bone is driven into the pelvic cavity, the symptoms are much more serious, on account of the associated injuries to the viscera and the greater amount of violence employed. The case will resemble one of fracture of the neck of the femur, but there is usually only very slight mobility, and the head may be felt within the pelvis on rectal examination. An attempt should be made to free it by horizontal traction outwards and manipulation through the rectum; extension is then maintained, and passive movement commenced early.

4. **Fracture of the Tuber Ischii** has been known to occur from falls in the sitting position. The diagnosis is often obscure, as the displacement is slight.

5. **Fracture of the Sacrum** is always due to direct violence of considerable severity, such as kicks, blows, or gunshot wounds. It is not unfrequently comminuted, and may be accompanied by injury to the bladder or rectum; damage to the lower sacral nerves may result in loss of power of these viscera. In a transverse fracture, the lower fragment is usually displaced forwards, and may cause pressure upon the rectum; irregularity in the shape of the bone may be detected by rectal examination or from without. **Treatment.**—The lower fragment should be replaced, if possible; but considerable difficulty may be experienced in keeping it in position. A well-fitting pelvic band, with rest in bed, is probably all that is necessary. Injury to the rectum with fæcal contamination of the wound may require colostomy.

6. **Fracture of the Coccyx** occurs during parturition or results from falls or blows, although its mobility often protects it from injury. Great pain is felt on walking, or on any movement which increases the intra-abdominal pressure, such as straining, coughing, defæcation, etc., since the coccygeus muscle forms part of the pelvic diaphragm. A rectal examination reveals preternatural mobility of the lower fragment, angular deformity, and perhaps crepitus. The **Treatment** consists in keeping the patient at rest until union has occurred; it is impossible to apply any apparatus, and hence the bone may unite at an angle, causing pain, discomfort, and difficulty in parturition. *Excision of the bone* is then required. The patient lies semi-prone with the legs slightly flexed, or in the lithotomy position, and a longitudinal incision is made in the middle line. The apex and lateral margins of the bone are cleared, and the ligamentous tissues uniting it to the sacrum divided by the knife; the bone is now laid hold of by sequestrum forceps, and its remaining attachments severed, due precautions being taken not to encroach on the rectum Two or three stitches are inserted, and also a drainage-tube for a few hours; the dressing is secured in position by a T-bandage. The bowels should be confined for some days after the operation.

Falls upon the coccyx, unaccompanied by fracture, sometimes give rise to a most severe and intractable type of neuralgia, known as **coccydynia,** which may quite prevent the patient from following his avocation. It is probably due to adhesions forming between the posterior sacral nerves and the bruised periosteum. If sedatives fail in giving relief, the bone must be excised.

Fractures of the Femur.

The multitudinous types of strain and violence to which this bone is exposed is the obvious reason why so many different varieties of fracture occur. The length and strength of the muscles governing its movements explain the degree of deformity often seen after its fracture, and the importance of its function both in weight-carrying and progression make the treatment of such an injury one of prime significance. Fractures of the femur must be studied according to their situation, and it is helpful to consider them according to whether they involve the upper end, the shaft, or the lower end.

Fractures of the Upper End of the Femur involve the head, the neck, or the trochanters, and several varieties are described:

1. **Fracture of the Cervix Femoris near the Head**—the *transcervical* or so-called *intracapsular* (Fig. 231). This is most frequently met with in persons of advanced age, and especially in females. This is explained by the atrophic changes which take place in the cervix femoris of elderly people. The spaces between the bony cancelli are enlarged and loaded with soft fat, whilst the ensheathing compact tissue is thinned and the 'calcar femorale' of Merkel

(*i.e.*, the process of thick cortical substance running from the lesser trochanter to the under part of the head) is atrophied. It often requires but little violence to produce this fracture, the causative accident being merely some slight stumble or fall, such as slipping off the kerb or tripping upstairs, the bone yields, and the patient falls to the ground. The line of fracture varies, being either transverse or oblique, and is mainly intracapsular. Some of the fibres reflected from the under surface of the capsule to the neck of the bone may remain untorn at first, but later on they may give way from reactionary softening, injudicious manipulation, or attempts to use the limb. The upper end of the neck is occasionally driven into the cancellous tissue of the head, but impaction is unusual. The *displacement* is limited entirely to the lower fragment, which is drawn upwards by the glutei, rectus, and hamstring muscles, and rotated outwards and backwards, so that its fractured surface looks almost directly forwards.

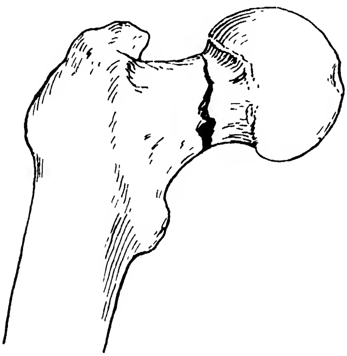


FIG. 231.—TRANSCERVICAL (INTRACAPSULAR) FRACTURE OF THE CERVIX FEMORIS.

The **symptoms** and **signs** of this lesion are tolerably characteristic. An elderly person in walking slips or trips; he may fall, but will complain at once of acute pain on moving the hip, which possibly is not the one upon which he fell. The leg lies in a helpless state and an everted position; there may be a certain amount of shortening, but it is not very marked. A more complete account of the clinical phenomena is given at p. 602, as also a few words on diagnosis.

The **course** of the case depends almost entirely upon the treatment adopted, and to a much less extent upon the age and health of the patient. If he is moderately healthy and free from chronic pulmonary disease, so that he can be kept recumbent for two or three months (and this is the case in the majority of patients), there is every reason to expect bony union in a considerable percentage, and that in spite of the poor blood-supply of the upper fragment and the fact that the fracture is intracapsular. In a few cases non-union occurs, owing to the presence of some reflected periosteal sores between the fragments, but as a rule it is due to no attempt having been made by the practitioner to encourage union by treating the limb in the correct position, and naturally a bad result follows. A loose fibrous union develops, and this may possibly permit of a backward displacement, the weight of the body being henceforth borne on the outer limb of the Y-ligament and the tendon of the obturator internus. In some cases the joint undergoes changes

akin to those seen in osteo-arthritis, and the patient henceforth suffers much pain and discomfort. Of course, in very old and feeble people the shock of the accident and the necessary interruption of the ordinary routine of life may throw out of gear the physical or mental machinery, and thereby cause death. But it must be repeated that in the majority of cases it is the practitioner's duty to attempt to secure union by effective treatment. The existence of impaction is, of course, of the greatest value, and the fear of breaking this down must be ever in the surgeon's mind.

Treatment.—It is important to realize that no influence can be exerted upon the upper fragment and that the lower end must be brought to it. To effect reduction, manual extension of the limb is necessary under a general anæsthetic, a roller towel round the perineum being employed for counter-extension. This is maintained until the limbs correspond in length, and then the leg is fully inverted, and the whole limb slowly and fully abducted under tension. By this means it is hoped that the two surfaces are brought into apposition, and there they need to be maintained for three or four months by means of a casing of plaster of Paris (Royal Whitman), re-applied if need be from time to time, or in a double abduction frame, practically consisting of a double Thomas's splint with the limbs apart (Sir R. Jones). It is necessary to watch the knee-joint in order to prevent stiffness, and the limb must be massaged and exercised freely before any attempt is made to permit the patient to stand or walk, and even then a calliper (Fig. 252) may be desirable.

If the fracture is primarily impacted, of course no attempt is made to break this down, and the prognosis is correspondingly improved. If the patient is too feeble to attempt such treatment as indicated above, all that can be done is to keep the limb at rest for a few days in bed, and then apply a plaster case, or a Thomas's splint, or a calliper, and let him get about on crutches as best he can.

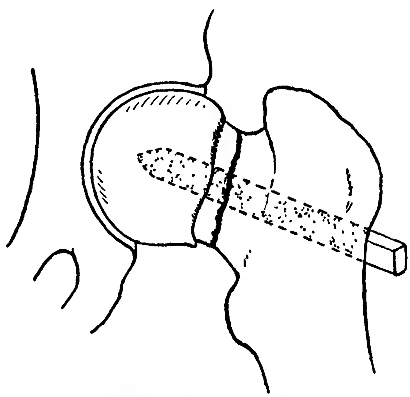


Fig. 232.—Method of Insertion of Bone-Peg for Transcervical Fracture of Cervix Femoris. (After Hey Groves.)

When the fracture remains ununited, and this is due to want of blood-supply to the upper fragment, want of apposition, or possibly the interposition of certain capsular fibres, it may be desirable in suitable cases to assist matters by inserting a peg or bone plug (Fig. 232), cut from tibia or fibula, through the bone, so as to hold the fragments together; it is introduced upwards and inwards

through a hole ⅜ inch in diameter drilled from the outer side of the trochanter through the neck into the head (usually a distance of 3 to 3½ inches); the bone peg must fit closely.

2. **Intertrochanteric Fracture of the Femur** (the so-called *extra-capsular fracture* of the neck) always involves the hip-joint, since the capsule extends to the shaft of the bone along the anterior intertrochanteric line, and leaves no portion of the neck uncovered in this situation. The line of fracture is therefore only extra-capsular behind (Figs. 233 and 234).

Mechanism.—It is usually the result of violence acting transversely upon the trochanter major, as from a heavy fall upon the hip. The posterior part of the neck, being weaker than the anterior, first gives way; the whole neck then yields, and the severed head and

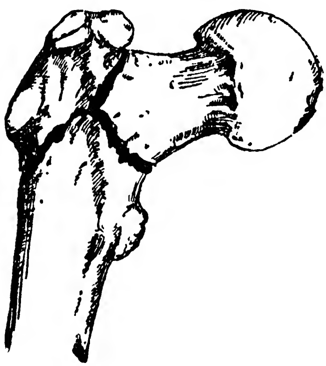


FIG. 233 — INTERTROCHANTERIC FRACTURE OF CERVIX FEMORIS. (SEMI-DIAGRAMMATIC, FROM THE FRONT.)

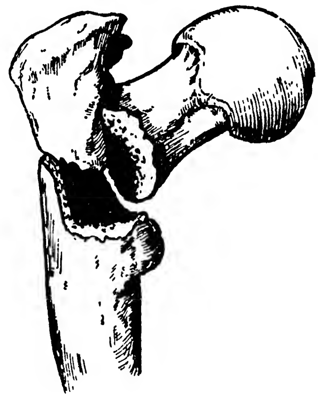


FIG. 234 — INTERTROCHANTERIC FRACTURE OF NECK OF FEMUR, SEEN FROM BEHIND. (COLLEGE OF SURGEONS' MUSEUM.)

The head and neck are depressed, and the trochanter major drawn slightly upwards.

neck are impacted into the junction of the trochanter and shaft. The majority of these cases are thus primarily impacted, continuation of the violence producing disimpaction, coupled either with detachment of one or both trochanters, or with comminution of the great trochanter; at least three, and perhaps four, fragments are thus produced (Fig. 234). Disimpaction may also follow at a later date from the rarefaction associated with the early stages of repair or from injudicious manipulation; and thus the shortening, which may at first be slight, often increases at the end of a few days. The upper fragment remains in the acetabulum, whilst the lower end is drawn up and everted.

Union of the fragments is much more certain in this variety than in the transcervical, and it is often accompanied by a considerable

development of callus, which may subsequently impair the movements of the limb, whilst secondary bending and late increase of the shortening may occur if the patient walks too soon.

The **Signs and Symptoms** of the transcervical and intertrochanteric may well be considered together, the points of similarity and contrast being in this way more effectually emphasized.

(*a*) The signs of *local trauma*, viz., pain, bruising, and swelling, may be present in both; but whilst slight in the transcervical variety, they are often very marked in the intertrochanteric.

(*b*) *Crepitus* is evident in the unimpacted forms of each; but it is unnecessary and, indeed, extremely unwise to elicit it by forcible manipulation, especially in the transcervical variety.

(*c*) *Loss of power* is perhaps more marked in the intertrochanteric form than in the transcervical. Cases of the latter in which the patient has been able to walk into hospital some days after the accident are not unknown, and are probably due to impaction.

(*d*) *Eversion* is a most characteristic feature in both varieties, the limb lying absolutely helpless on its outer side. This displacement is accredited to the natural weight of the limb, to the greater fragility of the back of the cervix, causing it to be more comminuted than the anterior surface, and, lastly, to the greater power of the external rotator muscles. *Inversion* has been met with in a few rare cases, but is probably due to the violence in the particular instance being directed from behind forwards, and to impaction of the fragments.

(*e*) *Shortening* is slight in the early stage of transcervical fractures, and much greater in the intertrochanteric, even reaching to 2½ or 3 inches. It is indicated by displacement of the trochanter upwards, due allowance being made for the position of the limb as regards abduction or adduction.

(*f*) The *position of the great trochanter* is of the greatest importance. It is raised above its ordinary level, and displaced backwards owing to eversion of the limb; and it is approximated to the middle line of the body. The demonstration of this position is most important, and, amongst others, the following tests are employed:

Nélaton's line (Fig. 235) is one drawn from the anterior superior spine to the most prominent point of the tuber ischii (AB). The centre of this (D) corresponds to the top of the great trochanter, if the limb is placed in the axis of the body, but if either abduction or adduction is present, the top is situated slightly above or below the line. Definite elevation of the bone above the line indicates shortening of the limb due to dislocation backwards, fracture of the neck, or absorption of the head and neck from disease.

Bryant's Test Line (Fig. 235).—In this the patient lies flat on a horizontal couch, and a vertical line (AC) is drawn from the anterior superior spine; a thin wooden rod held against the side answers this purpose admirably. The perpendicular distance of the top of the great trochanter from the line (CD) is compared with a similar measurement of the opposite side; definite shortening may thus be

discovered. In the normal adult this measurement is usually about $2\frac{1}{2}$ inches.

Morris's bitrochanteric test indicates the amount of inward displacement. It is conducted by measuring the distance between the outer surfaces of the trochanters and the middle line of the body by means of a rod graduated from the centre, along which two pointers work outwards. Shortening in this direction will also be observed in most dislocations of the hip-joint.

Moreover, in the intertrochanteric fracture a considerable amount of *broadening* of the trochanter is always produced, owing to the excessive development of callus. In the transcervical variety it is rarely fissured or injured, and therefore no change occurs.

(*g*) Lastly, *relaxation of the fascia* between the crest of the ilium and the great trochanter (that is, of the upper part of the ilio-tibial band) is given as a characteristic feature of these fractures.

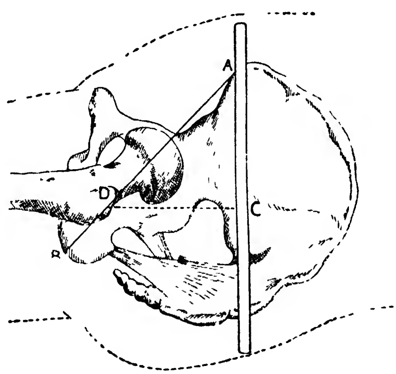


FIG 235.—NÉLATON'S LINE AND BRYANT'S MEASUREMENT FOR ASCERTAINING POSITION OF GREAT TROCHANTER

Diagnosis.—A *severe contusion* of the hip, which may be associated with marked eversion, is known from a fracture by the absence of shortening and crepitus; there is no displacement of the trochanter, which rotates in a normal manner. The shortening which sometimes follows, owing to subsequent atrophy of the neck, may, however, complicate matters. In a *dislocation* the head of the bone can be felt in an abnormal position, and hence no difficulty should be experienced in its recognition. In *chronic osteo-arthritis* of the hip a patient may fall and present for examination a limb with definite shortening and marked bony crepitus. It will be found, however, that there is no acute eversion, pain, or loss of power, whilst the existence of similar disease in other joints may assist the surgeon. Moreover, osteo-arthritis of the hip usually results in prominence of the trochanter, and not in flattening, as occurs after fracture; the fascia, too, above the trochanter is never relaxed in osteo-arthritis, always in fractures.

3. **Fracture through the Great Trochanter** (the *pertrochanteric* fracture of Kocher) closely resembles the intertrochanteric fracture, the lesion running from the inner and under part of the neck obliquely upwards and forwards through the base of the trochanter (Fig. 236, A) (R.S., Fig. 15). The lower fragment is displaced upwards and everted, and its upper edge can often be felt distinct from the top of the great trochanter, which does not move on rotation of the limb; there is also much thickening about the trochanter, and pain on pressure over it. This injury needs to be carefully distinguished from—

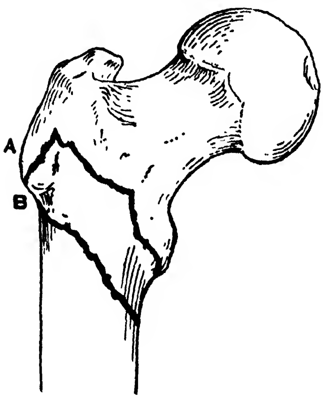


FIG 236.—A, PERTROCHANTERIC FRACTURE OF FEMUR; B, SUBTROCHANTERIC FRACTURE.

4. The *subtrochanteric* fracture, which encroaches on the upper end of the shaft. In this both trochanters are included in the upper fragment (Fig. 236, B), which is flexed by the ilio-psoas and abducted, whilst the lower fragment is drawn up on its outer aspect and behind it, with considerable shortening and complete eversion.

The **Treatment** of the inter-, per-, and sub-trochanteric fractures is conducted along lines similar to those employed for fractures of the shaft (p. 607)—viz., by prolonged and effective extension with suitable suspension. Not unfrequently the limb must be abducted in order to effect reduction of the fracture, and sometimes inversion is necessary; but in all cases treatment must be guided by radiography in order to ensure correct reposition of the fragments. Immobilization of the hip must be maintained for six or eight weeks; but long ere this movements of the knee must be commenced, and before any attempt at weight-bearing passive movements of the hip will be undertaken. A walking calliper (Fig. 252) must subsequently be used for some months.

Union occurs readily, but unless effective apposition of the fragments has been secured a good deal of deformity is likely to follow, with subsequent disability from bony outgrowths, and the limb may be shortened by the development of a traumatic coxa vara. Impacted fractures, therefore, in healthy patients should generally be broken up, and even open operation to secure this end with subsequent fixation in good position by screws, pegs, or plates is justifiable.

5. **Fracture of the Great Trochanter** is rare, and always due to direct violence; in the young it occurs as an epiphyseal lesion (Fig. 237). The trochanter, or a portion of it, is separated from the rest of the bone without any loss of the continuity of the shaft.

Independent movement of the fragment with crepitus is usually obtainable; and if the displacement is at all marked, an operation to fix it should be undertaken.

Fractures of the Shaft of the Femur are extremely common in spite of the apparent strength of the bone. Any part may be involved, particularly the centre, whilst they occur at the lower end more frequently than at the upper. In the latter situation they are usually due to indirect violence, whilst at the lower end they generally result from direct injury; either form of violence may lead to a fracture about the middle of the bone, and radiography has shown that spiral fractures are by no means uncommon. Exact diagnosis is sometimes difficult, owing to the amount of swelling from hæmorrhage, and to the muscularity of the part.

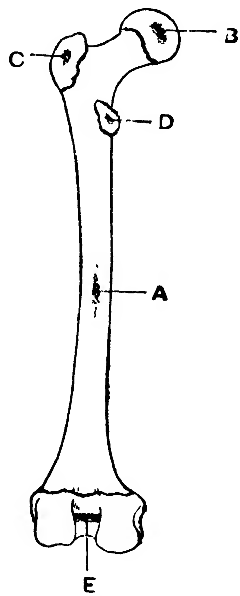


FIG. 237.—CENTRES OF OSSIFICATION OF FEMUR.

A, For shaft, eighth week of intra-uterine life; B, for head, first year, fusing with shaft at eighteenth year; C, for great trochanter, third year, fusing with shaft at eighteenth year; D, for lesser trochanter, twelfth year, fusing with shaft at eighteenth year; E, for lower epiphysis, at birth, fusing with shaft at twentieth year.

In almost every case *displacement* occurs, the direction and amount of which depend not only on the line of fracture, but also on the situation. In the *upper third* (Fig. 238), the small upper fragment is usually tilted forwards by the ilio-psoas, and abducted and everted by the gluteus minimus and external rotators; whilst the lower fragment is drawn upwards and to the inner side of the upper by the hamstring and adductor muscles, marked eversion also resulting, partly from the weight of the limb, and partly from the action of the adductors; but such a complicated displacement is not always present.

In the *middle third*, if due to indirect violence, the line of fracture usually slants from above downwards and backwards, causing a simple overriding of the fragments or an angular deformity. The lower fragment is drawn upwards and inwards, either in front of or behind the upper fragment, and is usually everted. The upper fragment is sometimes tilted forwards. If due to direct violence, the fracture is more or less transverse, often comminuted, and any

form of displacement may then occur. In either case there is extensive laceration of the quadriceps extensor muscle, and the sharp end of either fragment may be caught in its fibres, and reduction of the deformity thereby hindered. Considerable hæmorrhage follows, and a large collection of fluid blood around the ends of the bone sometimes impedes reduction and repair.

In the *lower third* the fractures which arise from direct force are transverse; the lower fragment may then be tilted backwards by the gastrocnemii muscles (Fig. 239), and compress or rupture the popliteal vessels, perhaps causing gangrene. Oblique or spiral fractures from indirect violence, sloping from above downwards and forwards, are also met with; the upper fragment is driven into the

FIG. 238.—FRACTURE OF UPPER THIRD OF FEMUR, SHOWING DISPLACEMENT OF BONE.

FIG. 239.—FRACTURE OF LOWER THIRD OF FEMUR, SHOWING DISPLACEMENT OF LOWER FRAGMENT BACKWARDS.

substance of the quadriceps muscle, and may become fixed in it, projecting immediately beneath the skin close to the upper border of the patella, whilst the lower fragment is drawn up behind. If such a case is left unreduced, non-union is likely to ensue; the knee-joint is generally penetrated by the lower end of the upper fragment.

Open (Compound) Fractures of the femur have been only too common during the past few years as the result of military activity, and may result from any form of gunshot wound. A rifle bullet travelling cleanly inflicts little damage on the soft tissues, and may traverse the cancellous structure of the femur near the neck or close to the knee without causing any solution of continuity; if, however, it hits the compact shaft, a complete fracture results, often with great comminution.

In civilian practice open fractures of the femur are generally the result of direct violence, such as street, railway, or machinery accidents; they are associated with much laceration and often with severe infection of the overlying soft tissues, and hence the patients, when first seen, are often in a condition of grave shock.

The history of these cases is very similar to that of all open fractures (p. 551); the peculiarities depend on the central position of the bone in the limb, rendering drainage and accurate fixation of the fragments more difficult. Consequently, infective troubles in the wound and of the bone are frequently observed. Necrosis is not uncommon, and, owing to the density of the compact bone, the sequestrum is long in separating; even when union occurs it may be associated with much shortening and deformity, and the knee may be stiff. Sinuses may persist for long, and the convalescence is often very slow.

The Treatment of Fractures of the Shaft of the Femur.—I. **Prolonged Extension** is necessary in some fractures of the upper end, and in almost all fractures of the shaft, if the fragments are to be satis-

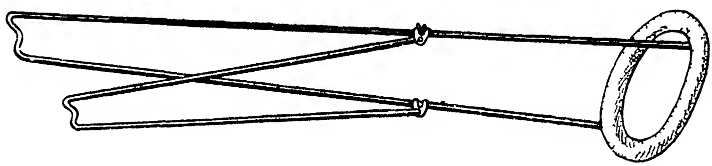


FIG. 240.—THOMAS'S SPLINT WITH MOVABLE LEG-PIECE TO PERMIT MOVEMENT OF KNEE-JOINT.

factorily replaced and shortening prevented. Powerful muscles are attached to the fragments, and to counter their activities effective extension is needed. For this purpose skeleton splints of the Thomas or Hodgen type must generally be employed.

Thomas's splint has already been described (p. 541), and in some form or other must be looked on as *the* splint for the treatment of a fractured femur. Various methods of applying extension are indicated below, and these can be employed according to the special requirements of the case. The chief objection to the Thomas's splint is that it is straight, and cases are not infrequent in which treatment should be undertaken with the knee flexed; moreover, efforts must always be made to keep the knee-joint movable, in order to prevent stiffness, and this is not easily arranged with an ordinary Thomas. This need is met either by bending the side-bars of the splint at the level of the knee, or by adding thereto an accessory leg-piece (Fig. 240) with a hinged attachment to which the lower section of the limb is fixed, the true lower end of the splint being utilized for suspension, and, if need be, for the fixation of the extension bands. A Hodgen's splint also meets the requirements of the case.

Hodgen's splint (Fig. 241) is similarly a skeleton splint, but instead of a ring has merely an arch at the upper end which crosses the upper surface of the thigh obliquely just below Poupart's ligament; the outer limb of the splint is therefore the longer. Before applying the splint, an adhesive plaster extension (p. 609) is attached to the limb. Strips of house-flannel, about 7 inches wide, are then arranged beneath the limb at right angles to its axis, and fixed as for a Thomas's splint (p. 541). The cord of the extension is then tied to the end of the splint. The splint thus supporting the limb is suspended by attaching cords to the hooks brazed to the sides of the frame; these are brought together over the limb, and to them another stout cord is tied which passes over a pulley attached to a vertical post at the end of the bed or to an overhead support. Of course, there is no reason why short thigh splints of the Gooch

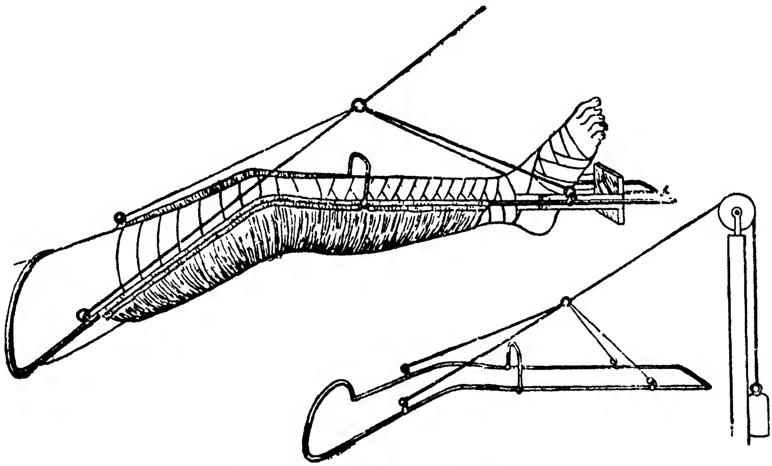


FIG. 241.—HODGEN'S SPLINT AND ITS METHOD OF APPLICATION.

type should not be incorporated in the dressing, so as further to immobilize the fragments. The patient's weight is the counter-extending force, and with that object in view the lower end of the bed must be raised on blocks. Sometimes even this is insufficient to prevent the splint from becoming loose, and then a weight attached by a cord to the upper arch and suspended from an overhead frame will be necessary. When correctly applied, the splint itself is pulled on by the extending force (the weight), and this is transmitted to the limb through the cord passing down from the 'spreaders,' which should be taut 'like a harp-string'; laxity of this cord indicates that the splint has slipped and necessitates re-adjustment.

Hodgen's splint is an admirable contrivance if correctly applied, in that the knee and hip joints are both slightly bent; but it is admittedly difficult to fix satisfactorily, and after all Thomas's splint properly handled fulfils all requirements.

The *methods of applying extension* to the leg for fractures of the femur are very various, and must be suitably modified to meet differing necessities.

1. *By Means of Adhesive Plaster.*—Before applying this the limb should be shaved, washed and purified so as to ensure a more secure hold for the plaster, and as far as possible to avoid irritation or septic troubles in the skin. Two strips of strapping about 2½ inches broad are cut and folded as in Fig. 242, and notched on either side so as to adapt themselves better to the rounded surface of the limb. They should reach well up the thigh, and not be attached over the

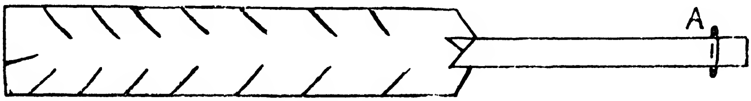


FIG. 242.—METHOD OF CUTTING AND FOLDING THE STRAPPING IN APPLYING EXTENSION.

line of the knee-joint, so as not to hinder early mobilization; to this end, a suitable short length of chamois leather should be stuck to the adhesive surface opposite the joint. A 'spreader' is then prepared as in Fig. 243; adhesive plaster is fixed to a piece of wood, rather broader than the ankle, with a hole in its centre for the passage of a cord. The long strips are applied on either side of the limb after warming or moistening with turpentine the adhesive surface, and secured to it by narrow strips of strapping passing obliquely round the limb covered by a woollen or boracic bandage, which need not extend much below the knee. The spreader is then

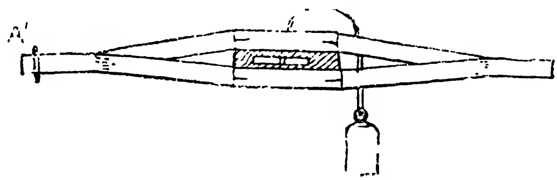


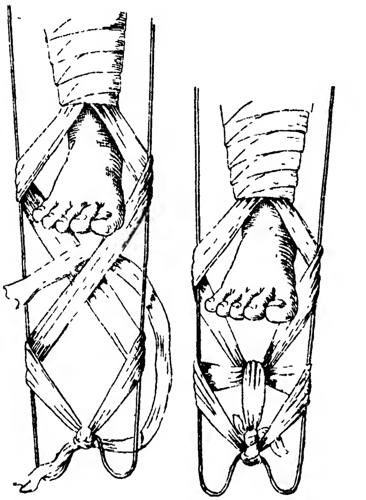
FIG. 243.—METHOD OF ARRANGING STRAPPING ON 'SPREADER.'

The end A′ is attached by a safety-pin to A, the end of the upper piece of strapping in Fig 242, and a similar attachment is made on the other side of the limb to the other piece of strapping.

attached by safety-pins or otherwise; the malleoli must be padded in order to protect them from friction. Through the hole in the centre of the spreader passes a cord, secured to a wooden cross-piece above, and below passing over a pulley suitably placed and having at its extremity the weight which acts as the extending force.

The weight employed necessarily varies with the size and muscular development of the patient, but in the past surgeons have generally erred in the direction of using too little. For a healthy adult it is often necessary to employ a weight of 20 pounds, in order to restore a broken femur to its normal length, and the foot of the bed must

be raised 12 inches to provide sufficient counter-extension. It is undesirable to apply the full weight at once, as the skin may be blistered or torn; it is well to start with 7 to 10 pounds, increasing it quickly up to the maximum required to reduce the shortening, and this is determined, if possible, by radiography. As soon as union has occurred, the weight may be reduced to one-half, and this is maintained for another two or three weeks. As a matter of fact, it is wise to aim at securing half an inch of lengthening of the limb as the result of the extension; when the weight is removed and the patient begins to move about, some secondary shortening always follows.



FIGS. 244 AND 245.—METHOD OF TYING EXTENSION STRIPS TO END OF THOMAS'S SPLINT TO MAKE TRACTION.

The ends are carried one over and one under the side-bars, and tied over the end-bar; the long tail of one end is then carried back over the point of crossing of the two and tied again over the end-bar.

In many cases the weight and pulley can be omitted, and the ends of the adhesive strips are tied firmly together over the U-shaped terminal cross-bar; one strip is carried over a side-bar, and the other under, before being knotted together. In this method the extension is not quite so severe as in the former, but it is continuous, even when the patient is moved about, and hence muscular spasm quickly disappears. It may be combined with some other form of extension, *e.g.* the traction calliper, if necessary.

2. Adhesive plaster is always liable to be unsatisfactory, and many forms of *glue* have been suggested to replace it. Sinclair's formula* is admirable, and gives excellent results. There is no necessity to shave the leg, but grease should be removed by washing with a solution of bicarbonate of soda. The glue is painted over the desired areas of the limb with a suitable shaving or painter's brush, and to these are applied suitable lengths from a roll of white gauze (3 to 4 inches

* Sinclair's glue is as follows:

Best cabinet-maker's glue	50 parts.
Water	50 ,,
Glycerine	2 ,,
Calcium chloride	2 ,,
Thymol	1 part.

This glue should be heated in a water-bath at a temperature of 100° F. before use.

wide, and eight layers thick). The ends of the gauze strips are tied to the end of the splint and tightened up in the manner indicated in Figs. 244 and 245; or a nail or piece of wood may be slipped between the gauze strips and twisted around 'in the manner of a Spanish windlass' till the necessary tension is obtained, and then fixed against the side-bars.

3. It is obvious that extension obtained by the above methods almost entirely depends on a direct pull in the straight line of the limb, and should a flexed position of the knee be required a considerable amount of the force employed is lost, and in some cases reduction is not effected. Under such circumstances a Thomas's splint bent at the knee is used. One adhesive plaster or glue extension is attached to the thigh on either side, and extension can be made in the axis of the femur by a suitable weight, the connecting cord passing over a pulley secured to an upright at the end of the bed. A second extension can be applied below the knee and tied to the cross-bar of the splint, thereby increasing the extending force. The splint is then slung to a hook on the vertical post, or suspended from an overhead beam.

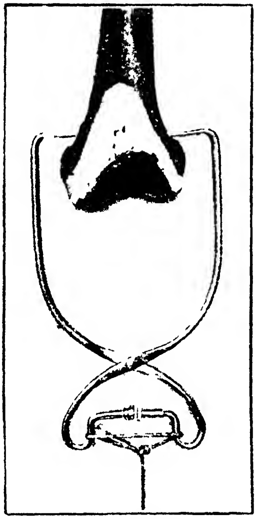


FIG 246.—TRACTION CALLIPER FOR USE IN FRACTURED FEMUR. (MAJOR PEARSON.)

It will be noticed that the points of the calliper rest against, and do not penetrate into the bone; moreover, the method of attachment of the extension cord below is such as to relax the pressure on the bone rather than to increase it.

Still more effective is the *Traction calliper*, such as that designed by Ransohoff or Major Besley (U.S.A.), and very similar in appearance to ice-tongs (Fig. 246). The points are introduced through the skin down to the surface of the condyles in front of the axis of movement of the knee-joint, which lies well to the back of the condyles. Traction is made from this by an extension weight as in Fig. 247, but the condition must be carefully watched so as to prevent hyper-extension of the lower fragment, which is quite a possibility; as soon as the alinement of the limb is restored, the extending weight must be diminished. It will be obvious from the illustration that early mobilization of the knee-joint is possible. The calliper should not be retained in position for more than three to five weeks; after this interval it is probable that simple weight extension of the limb without any splint will suffice to maintain the parts in good position, and active movements of the various joints may be permitted. Of course, the most minute care as to asepsis

must be adopted, and every precaution to prevent penetration of the knee-joint.

4. It is sometimes impossible or undesirable to fix the plaster or glued strips to the thigh or leg, and extension must then be made from the foot; this is, of course, especially applicable in fractures below the knee. For this purpose the following plans can be utilized:

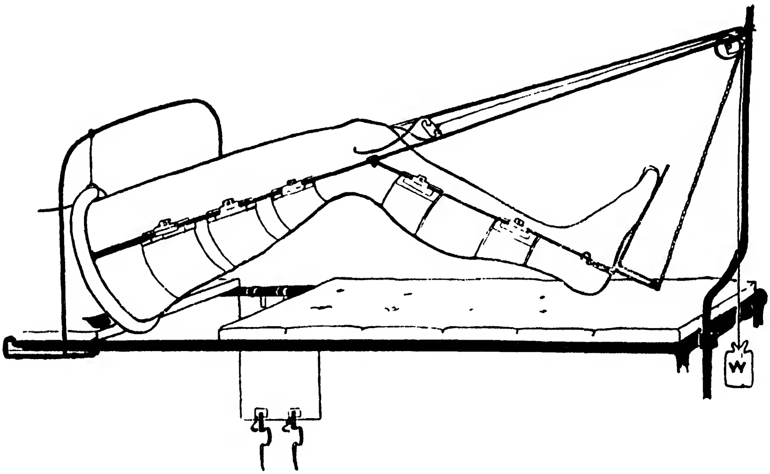


FIG. 247.—TRACTION CALLIPER IN USE FOR FRACTURED FEMUR. (BY THE COURTESY OF MAJOR PEARSON.)

The patient is lying on an Army pattern femur bed. A Thomas's splint with an adjustable leg-piece is in use; the latter is supported by a chain from a hook on the vertical upright. The calliper is in position; to the lower end the traction cord is attached to an hexagonal wire frame (not shown), resting on or sliding up or down the lateral bars of the Thomas, to the distal end of this frame is tied the actual extension cord. The transverse bar across the bed is of importance, as to it is attached a cord which draws the ring of the Thomas forwards, and keeps it in contact with the tuber ischii. Unnecessary details have, of course, been eliminated.

(*a*) **Sinclair's foot-piece,** or skate (Fig. 248). The wooden foot-piece carefully padded is applied to the sole, and fixed in position by adhesive plaster or glue. The situation of the iron cross-bar from which extension is made governs the position of the foot as to flexion or extension of the ankle; as a general rule the cross-bar should lie in the plane of the malleoli. Inversion or eversion of the ankle is controlled by adjusting the relative lengths of the tapes tied to either end.

(*b*) **Stocking Traction** (Fig. 249). A suitable sock (with the toes cut away) may be glued to the lower part of the leg, ankle, and dorsum of the foot, and a piece of splint or a metal rod suitably padded introduced between the sole and the sock. Traction is made by cords tied through the sock and passing under the splint.

Fixation may be effected even more certainly by plaster of Paris, a metal cross-bar with holes in the ends or with a hook below being incorporated in the dressing.

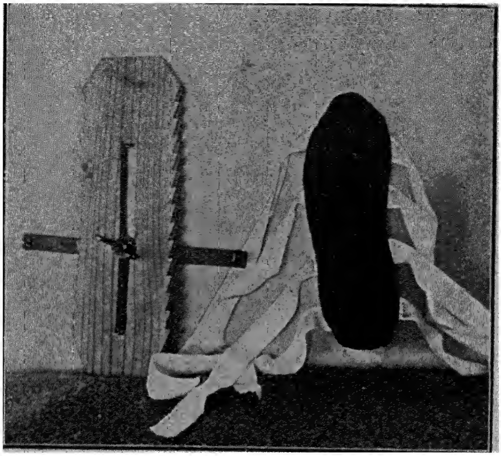


FIG. 248.—SINCLAIR'S SKATE, OR FOOT-PIECE, AND FELT PAD FOR FIXATION OF SAME.

II. **Suspension** of the limb has already (p. 539) been mentioned as one of the essentials if extension is to be really effective. To secure this for fractures of the femur, many contrivances have been devised.

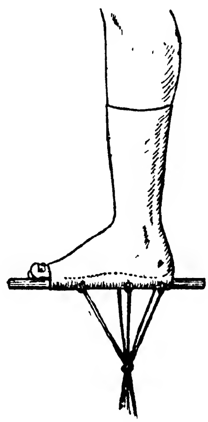


FIG. 249.—TRACTION BY STOCKING GLUED ON OR FIXED BY PLASTER OF PARIS.

The simplest consists in a wooden overhead bar (or *Balkan beam*) which reaches from one end of the bed to the other, resting on vertical posts with a solid floor support; this contrivance can be quickly knocked up by any carpenter (Fig. 253). It is usually placed slightly to one side of the median line of the bed so as to correspond to the axis of the affected thigh. The limb is slung by cords attached to the splint, both above and below, which pass over pulleys and have weights attached to act as counterpoises. A chain and handle fixed over the patient's head gives him the means of raising himself in bed; these movements are permissible and do not influence the position of the fragments when effective extension is present, and therefore simplify nursing. To the vertical post may be attached the pulley over which passes the extension cord, as also the end of the splint, when an accessory leg-piece is employed; the

latter is slung by a cord or chain from a hook in the vertical post (Fig. 247).

The mattress on which the patient lies may advisably be of the divided type (Fig. 250), so that removal of the central portion permits of access to the back and buttocks, which can thereby be better protected from bed-sores, and bed-pans, etc., can be more easily employed.

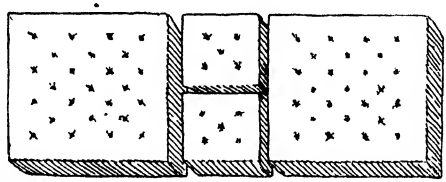


FIG. 250.—DIVIDED MATTRESS FOR TREATMANT OF FRACTURES OF THE PELVIS, FEMUR, ETC.

If suspension of the limb and splint is impossible, it is always practicable to keep the splint free of the bed so that the extension may act effectively. Thus the lower cross-bar of the Thomas's splint can rest on a suitable wooden block which raises it to a sufficient height; or a wire frame (Fig. 251) can be lashed to the bars of the splint, and on this the splint and limb rest.

The surgeon must never forget that the value of the extension arrangement he is employing depends almost entirely upon the

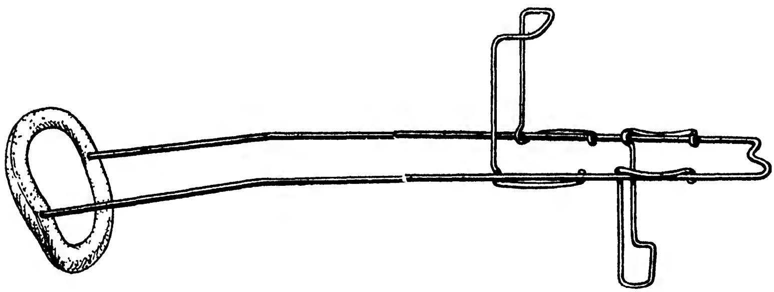


FIG. 251.—WIRE FRAMES LASHED TO SIDE-BARS OF THOMAS'S SPLINT—THE UPPER TO SUPPORT THE FOOT AND PREVENT FOOT-DROP, THE LOWER TO RAISE THE END OF THE SPLINT FROM THE BED.

existence of effective **counter-extension,** and this can be gained most surely by utilizing the weight of the body if the lower end of the bed be tilted up.

III. **Abduction** is not unfrequently required in the treatment of a fractured femur, especially at the upper end. The simplest plan is to utilize an oblique Balkan frame set across the bedstead from one corner to the opposite instead of being placed in the longitudinal axis. With the four-post frame it is easy to arrange for abduction by fixing the extension pulley, etc., to one of the lower side-posts.

IV. During the period that the patient remains in bed every effort must be made to *keep the knee and ankle joints supple and movable.* Of course, this is not always possible, as the joints themselves may have to be incorporated in the fixative dressing or in the apparatus used for extension; but whenever practicable, movements should be undertaken from an early date, and the means whereby this can be effected, whilst extension is still maintained, have been already indicated.

Foot-drop is another easily preventable complication in the absence of nerve lesions. A strip of gauze is glued to the sole, and from its upper end is carried an extension cord passing over a pulley attached to the Balkan beam at a point a little nearer to the patient's head. When the splint is not slung, but merely supported from below, a wire frame (Fig. 251) projecting upwards can be lashed to the side-bars, and to this the foot can be fixed in good position.

V. When the fracture has united, it is *not desirable* to put up the limb in plaster of Paris and allow the patient to get about on crutches unless the plaster case is removable so as to allow of massage and mobilization.

After a sufficient interval the patient should be given a *walking calliper* (Fig. 252), which consists of a leather-covered ring pushed well up to the buttock, so as to rest against the ischial tuberosity. To this ring are attached two metal bars, one on each side of the limb, which are bent at right angles below so as to fit into slots in the heel of the boot; thus the patient's weight is transmitted to the ground through the calliper and not through the limb, and then the patient can walk about without crutches and without risk of the union yielding. This appliance must be employed for at least six months from the date of the fracture.

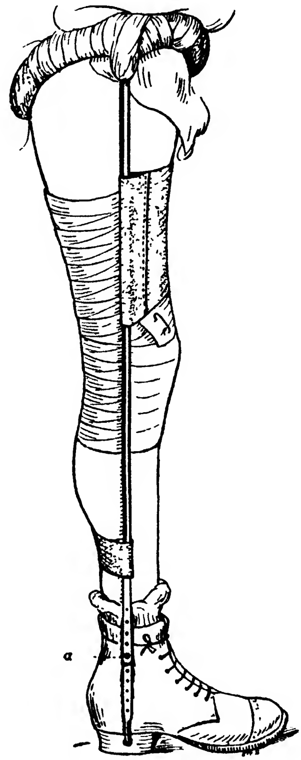


FIG. 252.—WALKING CALLIPER FOR USE AFTER FRACTURES OF THE LOWER EXTREMITY.

a indicates the position of a screw which fixes the overlapping ends of the two segments of which the appliance consists, thereby modifying the length for varying patients.

In the **upper third of the shaft of the femur** considerable difficulty arises in dealing with the short upper fragment, which is tilted for-

wards and abducted; it is too short to be controlled by any splint, and hence the deformity must be overcome by bringing the lower fragment into the same axis as the upper, thereby securing correct alinement. Extension must therefore be made on a Thomas's splint with the thigh well flexed and abducted about 40 degrees; a Hodgen's splint may here be useful, but the abduction required brings the ring of a Thomas's splint well against the tuber ischii, and hence good fixation is obtained. Counter-extension must be secured by raising the end of the bed about 12 inches. Of course, if it seems likely that the fragments can be better controlled by incorporating short pieces of Gooch's splinting into the dressing, this precaution should certainly be adopted. If in spite of these precautions the upper fragment projects unduly outward, deformity must be prevented either by the use of pressure pads as suggested at p. 541, or by the use of a bandage passing round the limb and attached to the inner side-bar, thus dragging the upper fragment inwards.

Unless accurate alinement is secured, vicious union with marked bowing-out of the thigh is likely to develop, or non-union with one fragment lying in front of the other. Hence in healthy patients serious difficulty in correcting the displacement or remedying the deformity is best countered by operation.

In the **middle third,** where both fragments can be controlled by splints, reduction is effected and shortening prevented by extension on a Thomas's splint, or a Hodgen, the thigh being also surrounded by pieces of Gooch splinting. Where there is no tendency to displacement, as in a closed transverse fracture, a half-box splint (*i.e.*, a long splint with a back-piece) may be successfully employed, the limb being firmly bandaged to the appliance. In oblique and spiral fractures, the tendency to overlap is considerable; if effective extension does not suffice to overcome impaction of the fragments in muscle fibres, operation must be undertaken.

In the **lower third,** where the lower fragment is tilted backwards by the gastrocnemius, extension in the flexed position of the knee is required. A Hodgen's splint is useful for this purpose; or perhaps better, a Thomas's splint bent at the knee with two sets of adhesive plaster extension—one below the knee to fix the limb to the splint, and one above the knee carried out in the axis of the femur. When this is not sufficient to tilt the lower fragment forwards, a traction calliper should be used (p. 611), but when once reduction is effected, the weight applied must be diminished.

Oblique fractures in this region are often difficult to correct, since the sharp lower end of the upper fragment penetrates the quadriceps and is entangled in its substance; if effective extension applied for a few days cannot effect reduction, open operation should be undertaken.

In children up to ten or twelve years of age, Bryant's plan of treatment (Fig. 253) is excellent. It consists in slinging up the limb at right angles to the body from an overhead beam, utilizing the child's weight as the extending force. Adhesive plaster exten-

sion is applied to both limbs; the sound leg is tied up out of the way; the injured limb may be tied to the beam, or a weight passing over a pulley may be utilized. In any case the child's pelvis should just be lifted from the mattress so that the body weight really acts; the insertion of an unnecessary pillow negatives the object desired. If abduction is also needed, the overhead beam should be set across the bed, and fixation effected as suggested above. This position is maintained for four or five weeks, and then the limb is loosened and massage and movements permitted, but the patient is not allowed to walk until a calliper has been fitted.

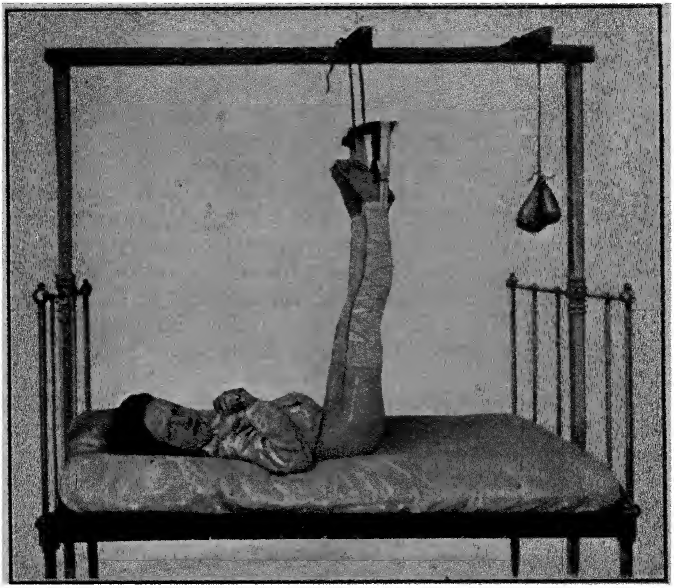


Fig. 253.—Bryant's Method of Extension for Treatment of Fracture of the Femur in Small Children.

The right leg is fractured, and has the weight attached to it; the left leg is merely tied up to keep it vertical and out of the way.

For the obstetric fracture which occurs in babies the best treatment is to apply a small Thomas's knee-splint with extension. The ring which encircles the groin is well padded and covered with impervious oilskin, and the extension is carefully maintained.

Operative Treatment for fractures of the shaft of the femur is very necessary in some cases. Surrounded as it is by a muscular bed, sometimes of great thickness and strength, it is almost impossible to influence the alinement of the fragments into which the femur is broken if extension fails in this object. Short splints and pads are of little use when opposed to powerful and healthy muscles;

and hence, in spite of all a surgeon's skill and effort, operation is sometimes required. One must, however, repeat the warning that it is a serious procedure, and must not be resorted to without due consideration or by those who are not expert in bone surgery.

In the **upper third** exposure of the fracture is made through an incision along the posterior aspect of the great trochanter downwards for a sufficient distance to enable the quadriceps to be turned forwards and the biceps backwards; the lower fibres of the gluteus maximus may need to be divided. Fixation is best secured by a plate with six or eight screws, it may be possible to reach the anterior as well as the posterior surface, and to this a second plate may be secured.

In the **middle third** the incision should be made to the outer aspect of the rectus femoris muscle, cutting through the substance of the vastus externus. Plates or wire are best adapted to secure alinement; with a very oblique fracture a couple of silver wire mattress sutures is perhaps the best means of fixation.

In the **lower third** operation is best undertaken through an incision on the outer side in front of the ilio-tibial band; but not unfrequently it is desirable also to have an incision on the inner side extending up from the internal condyle. Plates can then be fixed on both sides of the bone after reduction of the deformity.

Fractures of the lower end of the femur are of several different types.

1. **T- or Y-shaped Fracture of the Condyles.**—In this a transverse fracture close to the knee is complicated by a fissure which runs into the joint, separating the two condyles; or more frequently a Y-shaped fissure may start from the intercondyloid notch. The condition is very painful; the joint is distended with blood, the bone may feel broader than usual, and crepitus may be detected on grasping the knee. Comminution is not uncommon. **Treatment.**—An attempt at reduction must be made under an anæsthetic with the knee bent; the fragments should be grasped one in either hand, and brought together. If this is impossible, extension with the knee bent is applied, and possibly in a day or two reposition may become possible. Failing this, operation to fix the fragments by screws, nails, plates, or bone-pegs will be necessary.

2. **Separation of either Condyle** usually results from direct violence, but occasionally has followed such an indirect injury as catching the toe against the kerbstone. There is no shortening, but the leg may be deflected towards the side injured, and the knee-joint be full of blood. The fragment which is tilted backwards by the gastrocnemius may move separately from the shaft, and give rise to crepitus. **Treatment.**—Reposition is sometimes effected by flexion of the limb and manipulation, but in healthy adults treatment by operation is often desirable, the fragment being fixed by screws, bone-pegs, or plates.

3. **Separation of the Lower Epiphysis of the Femur** (Fig. 237, E) is not a rare accident, and is frequently due to a child sitting behind a cab and getting a leg entangled between the spokes of the revolving wheel. The limb is thus forcibly hyper-extended at the knee, and the epiphysis becomes detached and is carried forwards. The lower end of the diaphysis projects behind, and may compress the popliteal vessels; gangrene has been known to result. As in the humerus, the line of separation does not always correspond to the epiphyseal line, but sometimes encroaches on the shaft. Suppuration occurs in a fair proportion of the cases. **Treatment.**—Reduction is effected by an assistant making traction on the tibia in the line of the limb so as to stretch the quadriceps; then the thigh is gradually flexed by the surgeon, standing above and with both hands clasped beneath it. The epiphysis is by this means restored to its normal position, and the limb is kept flexed by a bandage at about an angle of 60°, and laid on its outer side with an icebag applied. Passive movement is commenced carefully in a fortnight.

Fractures of the Patella.

The patella is broken either by muscular force or by direct violence, and the conditions produced are so different that a separate description is necessary.

1. **Fractures by direct violence** may traverse the bone in any direction, but are most often vertical or star-shaped, and frequently comminuted. They are usually mere fissures without displacement, owing to the aponeurosis or capsule of the bone remaining intact. There is a good deal of subcutaneous bruising, and perhaps some effusion into the joint, whilst on careful palpation the fissure may be felt, and crepitus occasionally detected. **Treatment** consists in keeping the limb at rest on a back-splint, and perhaps applying evaporating lotions. Massage and passive movements are commenced early where there has been much hæmorrhage into the joint, and the use of a walking calliper permits the patient to get about at an early date. Operative measures are rarely required.

2. **Fractures due to muscular force** are always transverse, usually complete, and when they involve the fibrous aponeurosis, associated with considerable displacement.

Mechanism.—When the knee is semi-flexed, the patella is poised upon the front of the condyles of the femur, resting upon the middle of its articular surface; in this position any sudden and violent contraction of the quadriceps, as in attempting to recover one's equilibrium after having slipped, takes the bone at a disadvantage, and may succeed in snapping it (Fig. 254). Possibly in some people there is a predisposing weakness, as cases are not rare in which the other patella is broken at a later date. The fragments may be almost equal in size, but the lower is often the smaller; either of them may be again divided vertically, or comminuted (R.S., Fig. 16).

The **Signs** of this fracture consist of loss of power in the limb,

pain, distension of the joint with blood, and separation of the fragments, which can be readily felt and sometimes seen. This displacement is due to unopposed muscular action, and is not excessive unless associated with rupture of the lateral expansions of the vasti muscles. Union by bone is rarely obtained apart from operation, owing to the separation of the fragments, and the carrying in of loose tags of the fibrous aponeurosis or capsule, which yields at a different level to the bone. Fibrous union is the usual result, and when this is short and strong it is quite satisfactory; but more commonly the bond of union slowly yields when the limb is used, so that the two fragments are once again separated, merely a bridge of fibrous tissue intervening, the joint being left in a weak state, and the power of active extension of the leg much impaired or lost (Fig. 255).

FIG 254.—FRACTURE OF PATELLA, WITH SEPARATION OF FRAGMENTS.

The **Treatment** of these fractures may be grouped under two headings—viz., either by the use of simple retentive apparatus, or by open operation.

1. *Simple retentive apparatus* may be employed in cases where the fragments are not widely separated, and can be readily brought into contact, or where the patient is not a good subject for operation.

A large piece of moleskin plaster is applied over the front and sides of the extensor surface of the thigh, reaching half-way up to the groin, and terminating below in two lateral elongated ends or tags, to which elastic traction is applied. The limb is placed on a back-splint, with a foot-piece, beneath which the elastic accumulators are firmly fixed. Removal of the effusion in the joint may be hastened by the use of an aspirator. At the end of about three weeks the patient is allowed to get about on crutches, with his knee in a rigid splint, which can be easily removed for daily massage and passive movements. At the end of five or six weeks active movements are permitted. It is probable that only fibrous union is obtained by this method of treatment, but this is satisfactory and strong enough if the patient can give the time (6 to

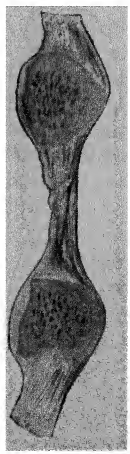


FIG 255.—FIBROUS UNION OF FRAGMENTS OF PATELLA (KING'S COLLEGE HOSPITAL MUSEUM.)

12 months) to ensure its solidification. The strength of this fibrous union is best illustrated by the fact that if the bone gives way a second time, the lesion takes place through the bony, and not through the fibrous, tissue. When, however, the patient has to work for his living, it is essential that repair should be established at as early a date as possible, and this can only be secured by operative treatment.

2. The *open plan of treatment*, originally advocated and perfected by Lord Lister, is undoubtedly the best, in that it permits of the removal of the tags of fascia and aponeurosis, which always intervene. It may be wise to delay operation for a few days in order that the joint may recover from the immediate effects of the injury.

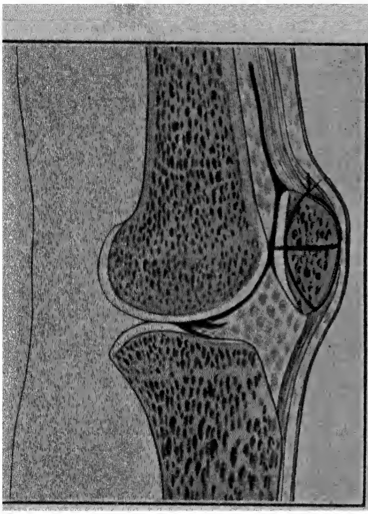


FIG 256.—LISTER'S PLAN OF SUTURING PATELLA BY OPEN OPERATION.

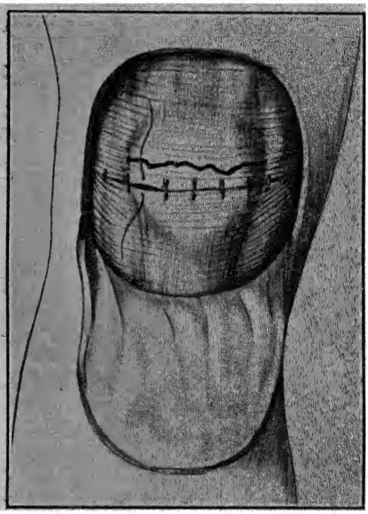


FIG. 257 —RESTORATION OF TRANSVERSE FRACTURE OF PATELLA BY CATGUT SUTURES APPROXIMATING THE FIBRO-PERIOSTEUM.

A horseshoe-shaped flap is turned down, exposing the fractured ends of the bone, which are cleared of all clot and fibrous shreds. Tracks for the wire sutures are now made by a drill, extending from the upper and lower ends through the centre of the bone, so as to emerge on the fractured surface just in front of the articular cartilage (Fig. 256); should the drill emerge at different levels on the faces of the fragments, cartilage or bone must be chipped away to make a channel in which the wire may lie, so that the two fragments are exactly level, with no inequality of the articular cartilage. A stout sterilized silver wire is then passed; the bones are brought into apposition, and the wire twisted into a knot or loop, which is hammered or pressed down into the tendinous or periosteal tissue

over the upper fragment, so as to keep it from projecting under the skin and causing irritation. A second wire is sometimes needed in order to prevent rotation of the fragments. The wound is closed, and the limb kept on a back-splint. In healthy adults passive movement may commence in ten days, and by the end of a fortnight the patient is allowed to walk in the simpler cases; but in complicated fractures and in elderly people it is better to keep the limb immobilized for a little longer period.

Of recent years there has been a considerable reaction against the method of burying silver wire in the tissues, especially when passing through a bone exposed to tension or movement. The wire may become disintegrated and break, or rarefactive osteitis may be caused thereby. Surgeons at the present time are rather favouring methods which depend on absorbable ligatures in the form of unchromicized catgut. The joint is opened and cleansed of blood-clot, and loose fibrous tags are removed. Antero-posterior *cerclage* of the bone with two or three strands of stout catgut is undertaken, and after bringing the fragments into apposition by manipulation, these are firmly tied (Fig 258). The rent in the fibro-periosteum and lateral tendinous expansions is also closed by sutures. In cases where there is but little displacement, the cerclage sutures may be omitted; in others, especially when the bone is in more than two fragments, a circumferential cerclage may be desirable as an added precaution. After-treatment is much as indicated above, but active movements are perhaps commenced a little later, in that catgut is being relied on, and not silver wire, to maintain the co-apposition of the fragments until the time when osseous union is fully established.

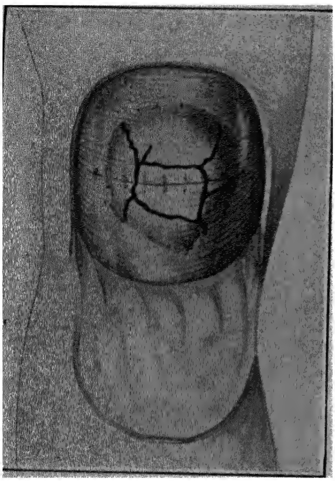


FIG 258 —COMMINUTED FRACTURE OF PATELLA TREATED BY INTERRUPTED SUTURES.

In *old cases*, where the fibrous union has stretched and the utility of the limb is seriously impaired, operation holds out the only hope of helping the patient. The fibrous tissue must be dissected away, and the surfaces of the fragments freshened, if need be, with the saw, and drilled for the passage of the wire. To obtain apposition, the upper fragment must be detached from the femur, to which it is often adherent, and the rectus muscle, which is secondarily contracted, is partially divided by alternating notches on either side. The limb should be well raised to relax the quadriceps, and thus diminish tension on the bond of union, and lowered inch by inch

on succeeding days. The muscle is thus stretched to accommodate itself to the altered conditions.

If the fragments cannot be brought absolutely together, the same treatment may be adopted, and the patient allowed to get about with a loop of silver wire between the fragments; the quadriceps is stretched by this means, and a subsequent operation may prove successful in gaining bony union.

Fractures of the Leg.

Fractures of the Tibia alone.—Several varieties are described. (*a*) The **upper end** is usually broken as a result of direct violence, the fracture being often comminuted. The characteristic features are not always very evident apart from radiography, since considerable swelling and ecchymosis are produced. Occasionally, as a result of falls on the heel, a T-shaped fracture occurs, the tuberosities being broken off and the upper end of the shaft impacted into one or both of them. A few cases of vertical separation of one of the tuberosities alone are also on record. **Treatment** consists in placing the limb upon a back-splint, *e.g.* Macintyre's, with the knee bent, and, as a rule, satisfactory union ensues, though possibly with some distortion. Displaced tuberosities should, if possible, be manipulated back into position under an anæsthetic, and fixed by a strip of plaster or a bandage. If the limb is then kept at rest on a Thomas's splint for a few weeks, there is little likelihood of the displacement recurring, but some impairment of function may result.

(*b*) Fracture of **the shaft** of the tibia, apart from the fibula, is usually caused by direct violence. It is transverse in the upper part of the bone, and oblique below. The fracture is diagnosed by feeling an inequality on running the fingers along the shin, together with pain at this spot on firmly grasping the bones above and below. There is often but little displacement, since the fibula acts as a splint, but the lower end of the upper fragment, which is usually pointed, is tilted forwards by the action of the quadriceps, and may pierce the skin. The **Treatment** consists in the application of back or side splints (Cline's), for a few days until the swelling has gone down, and then the limb may be put up in plaster. If the bone has been comminuted, treatment will be more protracted. In some cases reposition may be difficult, and then persistent traction from the foot with the knee flexed in a bent Thomas's splint will be required, and, failing this, operative treatment.

(*c*) The **internal malleolus** is occasionally separated as the result of direct injury, apart from any other osseous lesions, constituting what is known as *Wagstaffe's fracture*. There is comparatively little displacement, but the malleolus is loose, and crepitus can usually be obtained on moving it backwards and forwards. Union by fibrous or osseous tissue ensues, but often in a more or less abnormal position, in consequence of which the integrity of the ankle-

joint is disturbed, and weakness or lameness may follow. **Treatment** consists in bringing the fragment into position by inversion of the foot and manipulation, and maintaining this by strapping or plaster of Paris for some weeks; massage and gentle movements are, of course, allowed after a week or ten days, but only if the movements are painless. Failure in reposition of the fragment necessitates its fixation by operation; a bone-peg is the best to use.

Fractures of the Fibula alone are by no means uncommon, usually occurring as a result of direct violence, except when near the ankle (*q.v.*). There is no displacement or deformity; but the patient complains of pain localized to some particular spot, and this can usually be elicited by grasping the bones above and below, and compressing them laterally ('springing' the fibula). Radiography will make the diagnosis clear. **Treatment** consists in keeping the limb at rest for a few days, and then putting on a plaster case, which is removed daily for massage and movements.

Fracture of both Tibia and Fibula is a very common accident, due to both direct and indirect violence; if to direct violence, any part may be injured, both bones yielding at the same level; but if in consequence of an indirect injury, the tibia usually gives way at its weakest part, viz., at the junction of its middle and lower thirds, and the fibula at a higher level. The fractures are often oblique, running in any direction, although the obliquity is most frequently directed downwards, forwards, and inwards. The lower fragment is generally drawn upwards on account of the contraction of the powerful calf muscles, and often rotated outwards from the weight of the foot; hence there is well-marked shortening. The ordinary characteristics of a fracture are very evident, and but little difficulty can ever be experienced in making a diagnosis. The fracture is likely to become compound when due to indirect violence, owing to the sharp end of the upper fragment of the tibia piercing the skin.

The fracture of the tibia has been proved by radiography to be frequently of a spiral character, and is then probably always due as much to forcible torsion of the limb as to vertical strain. The rotation is an important element, and the shortening is sometimes less marked than in simple oblique fractures; there is frequently some difficulty in getting satisfactory approximation of the fragments, even on operation, owing to the broken ends becoming engaged in the fibro-muscular tissues around.

Treatment.—In the simpler cases reduction is accomplished by flexing and fixing the knee, so as to relax the muscles of the calf, and then making traction on the foot and manipulating the parts into position. The tendo Achillis may, if necessary, be divided. It will usually suffice to put up the limb in side-splints, such as Cline's, the longer one with the foot-piece being intended for the outer side. In other cases it may be better to apply a broad posterior splint with a rectangular foot-piece, *e.g.* Macintyre's or Neville's, and two lateral splints; or the old-fashioned half-box splint may be em-

ployed. It is always necessary to see that the length of the limb is as far as possible maintained, and that no rotation of the lower fragments is present. To ensure absence of rotation, all that is needed is to note that the inner aspect of the great toe, the subcutaneous surface of the internal malleolus, and the inner border of the patella, are in the same plane, and correspond with their position in the opposite limb. Union will be sufficiently advanced in two or three weeks at the latest to allow of the application of a removable plaster casing, which must be taken off daily for purposes of massage, but in spite of this much subsequent lameness is a frequent result.

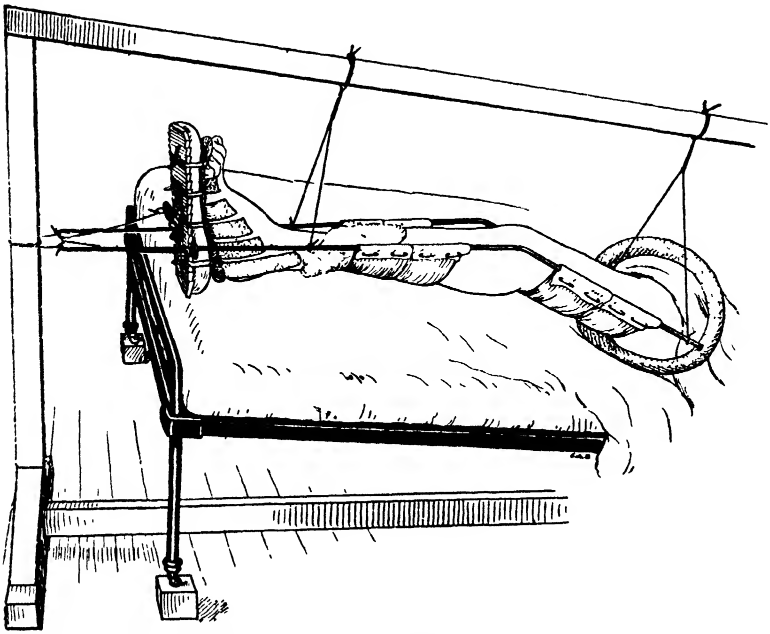


FIG. 259.—TREATMENT OF COMPOUND FRACTURE OF TIBIA AND FIBULA ON THOMAS'S SPLINT SLUNG FROM A BALKAN BEAM.

Extension is made from a Sinclair's foot-piece. For details of arrangement of foot-piece, see Fig. 248.

In the more complicated fractures of both bones, where there is a good deal of shortening, prolonged extension must be maintained with a flexed knee in order to relax the muscles attached to the tendo Achillis. The best apparatus to adopt is a bent Thomas's knee-splint (Fig. 259), slung from a Balkan beam, extension being made from a Sinclair's foot-piece glued to the sole or from a stocking tractor (p. 613); it may even be desirable to make extension by a traction calliper (p. 611) applied to the malleoli. When once sufficient extension has been made, the fragments fall into position by themselves, or can be manipulated into position, and kept

therein by suitable bands attached to the side-bars (p. 541). Lateral splints may be of use.

Looking to the facts that reduction by this means is not always easy or effective, and that extension does not always overcome the entangling of the ends of the fragments in the surrounding muscles, and that permanent deformity and disability to a considerable extent follow these fractures, unless early and satisfactory reduction and restoration of the correct alinement of the bones are secured, one has nowadays no hesitation in cutting down on and fixing by plate, wire, or bone-peg, any fracture of the tibia and fibula which is not readily reduced into good position, and especially fractures of the spiral type. If a plate is used, it may with advantage be placed on the outer aspect of the tibia under cover of the tibialis anticus, and there is no need to employ very heavy or thick plates, since the tendency to displacement later is not great if the knee is well flexed.

Fractures in the neighbourhood of the Ankle-joint are usually produced by indirect violence, such as wrenches, twists, slips, or falls on the feet. Lateral displacement of the abduction or adduction type was formerly considered to be the chief cause, but radiography has demonstrated that forced movements of version are even more important and frequently accompany the former—eversion with abduction, and inversion with adduction—and the resulting fractures are correspondingly modified. In addition, when once the tibio-fibular mortice has been impaired, the weight of the body aggravates the mischief, whilst the back-push of the foot may damage the posterior margin of the tibia, causing the so-called marginal fracture which complicates many of the more serious lesions. These accidents should therefore be termed *Fracture-dislocations of the Ankle*.

1. Fractures due to **Displacement of the Foot outwards** constitute by far the largest and most important group. They result from the patient slipping on the inner side of the foot, as from off a kerbstone. The two elements of version and abduction enter into and colour the picture, and may be combined in many ways to produce various types of injury.

(*a*) In the *simpler* forms, one or both bones may be broken, but there is no lateral displacement of the foot and astragalus if the inferior tibio-fibular ligament remains intact. When the foot is forcibly displaced outwards, the strain mainly falls upon the internal lateral ligament, and this gives way or the internal malleolus is torn off if the stress is too severe. The astragalus is thereupon driven outwards against the external malleolus, and excess of violence leads to fracture.

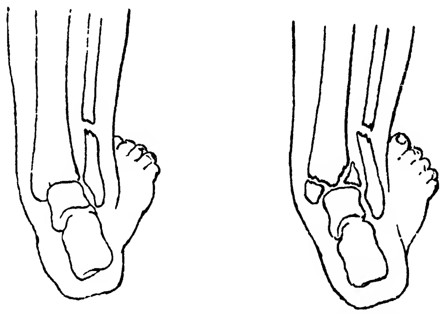
When *eversion* is the chief cause of the lesion, the fracture is generally oblique from above downwards and forwards; it may pass through the malleolus or be situated above it, but, of course, in the latter case there is more deformity.

In the *abduction* type the fibular fracture is more or less trans-

verse, the upper end of the lower fragment being displaced inwards. It is possible for both malleoli to be broken off at their bases and displaced inwards or outwards, but this *bi-malleolar fracture* is very uncommon and of a different character entirely. In the abduction group the fibula is usually broken just above the malleolus, but often somewhat higher. It was to a fracture of this type placed about 3 inches above the tip of the malleolus and associated with injury to the internal malleolus or internal lateral ligament with marked abduction of the foot that the term *Pott's Fracture* (Fig. 260) was originally applied.

When forcible eversion and abduction are combined in producing the fracture, a more complicated type of injury may result, and not unfrequently some degree of comminution may co-exist.

(*b*) A much more serious injury is that to which the term *Dupuytren's fracture* (Fig. 261) has been applied. In this the interosseous tibio-fibular ligament yields more or less completely, or the flake



FIGS. 260 AND 261.—DIAGRAMS OF POTT'S AND DUPUYTREN'S FRACTURES SEEN FROM BEHIND TO SHOW DEFORMITY AND LESIONS IN THE BONES.

of the tibia to which it is attached is torn off; the foot, carrying with it the lower portion of the fibula and the superficial flake of the tibia, which has been detached, is displaced firstly outwards, and so long as the upper surface of the astragalus does not clear the lower articular surface of the tibia, there is merely lateral displacement with marked abduction of the foot and increased breadth of the ankle. Should the force continue to act, the astragalus may be carried sufficiently outwards to clear the lower end of the tibia, and then an upward and to a less degree a backward displacement is added, causing great eversion of the foot and deformity of the ankle. On the inner side either the ligament or the malleolus may yield. It is often associated with a marginal fracture of the posterior lip of the tibia.

(*c*) In another variety the injury consists in the usual type of fracture of the fibula, associated with an almost transverse fracture of the tiba, just above the base of the inner malleolus. In this form the lower end of the shaft of the tibia projects beneath the skin, and

is likely to be mistaken for the tip of the malleolus; if this error is committed, and the fracture allowed to unite without proper rectification, considerable deformity results (Fig. 262).

(*d*) A similar injury in children and young people may produce a separation of the lower epiphysis of the tibia, whilst the fibula yields at a higher level. The line of separation in the tibia is more or less transverse, but may extend into the diaphysis on the outer side.

Fig. 262.—Malunited Supra-malleolar Fracture showing Characteristic Abduction and Eversion.

(*e*) Finally, in not a few cases wedge-shaped *marginal* chips may be broken off the anterior or posterior edges of the articular surface of the tibia, according to the direction of the violence.

In almost all of these varieties the ankle-joint itself is involved, and this, combined with the amount of bleeding that occurs into tendon sheaths and muscles around, and the difficulties sometimes experienced in complete reduction, explains why the results are frequently so unsatisfactory. Sometimes after union has occurred pain and deformity become increased owing to the patient being allowed to walk too early, the result being that the callus yields to the weight of the body. Should union occur with the foot in a false (*i.e.* everted) position, a large mass of callus develops between the shaft of the tibia and the malleolar fragment (Fig. 262).

2. *Displacement of the Foot inwards.*—When the patient slips on the outer aspect of the foot, the astragalus is forcibly driven against the inner malleolus, which may be broken off or impacted into it. The outer malleolus is dragged inwards with the foot, and owing to the integrity of the inferior tibio-fibular ligament, which acts as a fulcrum, the fibula yields at the same spot as in Pott's fracture. The foot is displaced inwards, and perhaps slightly backwards.

3. *Displacement of the Foot backwards*, by catching the heel and tripping forwards, is usually associated with fractures of the tibia and fibula through or just above the malleoli, but eversion of the foot is absent (see dislocation of the ankle backwards, p. 712).

It is essential in all injuries of the ankle to have a thorough radiographic examination, which should be both antero-posterior and lateral. The importance of this is evident from the facts that many

an oblique fracture of the internal malleolus is scarcely visible in an antero-posterior radiograph, although very evident displacement is really present. It is also most desirable that the limb should be again radiographed after reduction and fixation, as it is extremely easy for some recurrence of the displacement to take place during the application of the retentive dressing.

Treatment.—The surgeon cannot exercise too much care in the reduction of the deformity caused by these fractures. The following points must be carefully noted: (*a*) The foot must be at right angles to the leg, and with this object in view treatment must be conducted, at any rate for a time, with the knee bent so as to relax the tendo Achillis. (*b*) The heel must not project unduly backwards, thereby indicating that reduction has not been perfectly accomplished. The articular surface of the astragalus should be within the grasp of the tibio-fibular mortice, and there must be neither anterior nor posterior projection if movements are to be subsequently free. (*c*) Lateral displacement and torsion must also be corrected, and apart from radiography this is secured when the inner surface of the great toe, the internal malleolus, and the inner edge of the patella are in the same plane. It is well, however, to compare the foot with its fellow, and in bad cases to have the limb radiographed after reduction.

In reducing these fractures, therefore, the knee must be flexed and counter-extension made therefrom; traction is then exercised upon the foot to overcome both the antero-posterior, the lateral, and the rotary displacements. Manipulation will determine that a broken internal malleolus is in apposition with the shaft, and that the anterior edge of the tibia does not project unduly over the articular surface of the astragalus. The limb is advisably placed and maintained in a position of slight varus and complete dorsiflexion.

In very slight cases where there is little or no displacement, no retentive apparatus is required except a light plaster case, easily removable for massage and passive movements, which may commence quite early.

In the more serious cases the surgeon has to determine whether he can depend on conservative measures for the treatment of the case, or whether operation is necessary.

In emergencies when other means are not available, Dupuytren's splint may be employed. It is really nothing but a short straight splint, reaching from the knee to below the sole of the foot, and can be readily improvised. It is applied to the inner side of the leg with the patient lying on the sound side and the knee fully flexed. A firm pad extends down as far as the base of the internal malleolus, and over this as a fulcrum the foot is drawn inwards by a handkerchief, applied round the ankle and tied to the prongs or notches with which the splint terminates. The foot being thus fixed, the upper end of the splint is bandaged to the limb. It is difficult to prevent backward displacement of the ankle by this means, and for this reason it should only be used as a temporary measure.

Delbet's Ambulatory Treatment.—This is a very useful method of treating fractures in the neighbourhood of the ankle-joint. Four strips of muslin are cut into sizes and thickness as shown in the diagram (Fig. 263). The patient is placed on a flat plaster table,

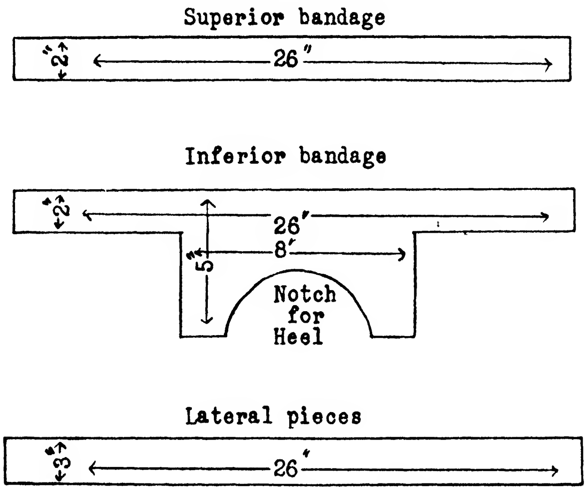


FIG. 263.—PLASTER BANDAGES REQUIRED IN DELBET'S METHOD.

and the leg and ankle are rubbed over with olive oil; an extension of 20 to 40 pounds is obtained by means of a skeleton tape spat (Fig. 264), so as to enable the broken fragments to be manipulated into good position. The four strips of muslin are soaked in plaster

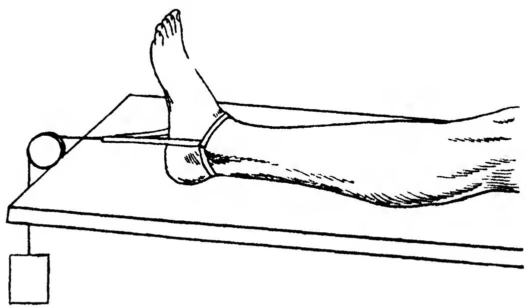


FIG. 264.—SKELETON SPAT APPLIED TO THE FOOT WITH EXTENSION.

cream.* The upper and lower bandages are passed behind the leg, and then the lateral pieces are placed in position (Fig. 265), so that their upper margins reach the level of the anterior tubercle of the tibia, whilst the lower ends are folded back ½ inch from the sole of

* This consists of 2 pints of plaster of Paris and 2 pints of cold water.

the foot. The upper and lower bandages are then folded over the lateral ones as shown in the diagram (Fig. 265). The lower bandage should cross about 1½ to 2 inches above the ankle-joint. The plaster bandages are further moulded to the malleoli and held in place by means of a small many-tailed bandage. The extension is maintained until the plaster is hard, and it can be removed by cutting the tape which crosses in front of the ankle-joint. The many-tailed bandage should not be removed for twelve hours, when the patient is allowed to put his foot to the ground and try to dorsi-flex at the ankle-joint without raising the heel from the ground. After two or three days, walking with the aid of sticks should be commenced, if a skiagram shows that the position of the bones is good. There may be some swelling around the ankle-joint at first, but this rapidly disappears if the leg is kept up for a day. New plaster will be required if the first one becomes loose. Generally

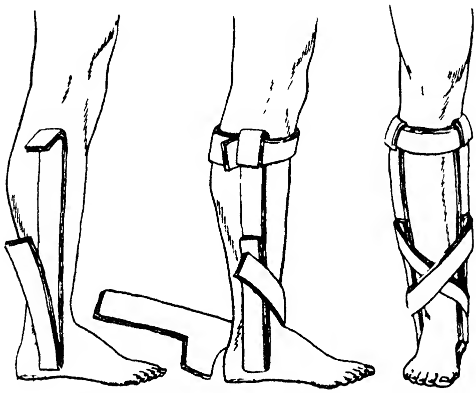


FIG. 265.—METHOD OF APPLYING DELBET PLASTER.

speaking, the plaster can be dispensed with after six or eight weeks. The great advantages of Delbet's method are early union and rapid recovery of function.

Operative treatment is quite justified in cases where it is impossible to reduce the fragments by manipulation under a general anæsthetic. The replacement of the astragalus in a complete tibio-fibular mortice is so important that surgeons should not hesitate, when asepsis can be assured and the necessary manipulative skill is available, to cut down on and fix by plates or screws the separated fragments. A short plate on the fibula reaching above and below the line of fracture has a wonderful steadying effect upon the parts, especially if one of the screws be of sufficient length to traverse the fibula completely and penetrate the tibia; it can be easily removed under a local anæsthetic at a later date when it has done its work.

In cases of vicious union after Pott's fracture, it is usually necessary to re-divide the fibula, and to excise a **V**-shaped portion of

the tibia, perhaps extending into the ankle-joint, so as to enable the malleolus to be brought into contact with the shaft. The lower fragment must be fixed to the upper by a plate screw, or peg.

Attention has already been drawn (p. 629) to a serious sequela of the fractures induced by abduction and eversion (and these probably constitute 90 per cent. of the whole)—viz., the development of flat-foot. Naturally it results from an unremedied displacement; but even when reduction has been effectively secured and the bones have healed in good position, it may occur if walking is permitted too early, or especially if the arch of the foot is not sufficiently supported, and the weight deflected to the outer side by increasing the thickness of the sole of the boot on the inner, whilst the use of a walking calliper is another necessary precaution.

Fracture of the Os Calcis may result from direct violence, such as a blow or fall on the heel, or possibly from muscular action, the epiphysis being then separated, or the shell of bone into which the tendo Achillis is inserted being torn off. The fragment thus separated is displaced upwards by the contraction of the calf muscles, and the resulting deformity is very evident. If the line of fracture passes through the body of the bone, there may be no displacement, owing to the attachment of the interosseous and lateral ligaments (R.S., Fig. 17); but should the sustentaculum tali or greater process be broken, the arch of the foot may be more or less flattened. When due to a fall from a height, the bone is often comminuted, and the foot much bruised and swollen (*compression fracture*). **Treatment** consists in immobilizing the foot in a plaster case if there is no displacement; but where the posterior part of the bone is drawn upwards, it must be approximated to the rest of the bone by flexing the leg in order to relax the calf muscles, or possibly tenotomy may be required. A more satisfactory result may, however, be obtained by cutting down, and wiring or pegging. In fractures which are likely to be followed by traumatic flat-foot, the patient must not be allowed to walk without an effective support, and the foot must be maintained in a slight varus position.

Fracture of the Astragalus is usually due to falls on the foot from a height, or from direct violence applied to the foot, as by a weight falling upon it. The lesion is often a severe comminuted one, and portions of the bone may be displaced forwards or backwards, making a marked projection beneath the skin. These accidents are often associated with lesions of the tibia or fibula, and possibly even of the femur. The whole region of the ankle becomes infiltrated with blood, and an exact diagnosis is sometimes difficult. **Treatment** consists either in immobilization, which is likely to be followed by stiffness of the ankle, or in bad cases in excision of the bone or of projecting fragments.

Occasionally in less severe accidents the bone merely splits across, the lesion being usually situated about the neck. This is due either to the weight of the body flattening out the arch of the bone beyond the limits of elasticity, or, if the foot is dorsiflexed, to penetration of

the bone by the anterior edge of the tibia, impaction being sometimes produced in this way. Massage and early mobilization should be employed in these cases, but the foot must be well supported by an instep pad before the patient is permitted to carry his weight, or a painful traumatic flat-foot will certainly result.

Fractures of the Metatarsal bones are quite common, and usually result from direct violence; occasionally they have been caused by prolonged marching with a heavy kit, and apparently with no special violence. Displacement is not very marked except when more than one bone is affected. **Treatment** consists in rest and massage, but before the patient is permitted to walk a suitable instep support must be supplied to maintain the arch of the foot. Only the heads of the metatarsals reach the ground, except in the case of the fifth; consequently the body weight tends to flatten out the arch at the expense of the new callus until it has become really strong. Thickening the inner aspect of the heel and sole of the boot, thereby throwing the weight to the outer side, will also be helpful

CHAPTER XXI.

DISEASES OF BONE.

General Considerations.—Bones are divided into the long, the short, and the flat, each of these consisting of compact and cancellous tissue. In the short bones there is but a thin layer of compact tissue surrounding a cancellous central mass, the meshes of which are filled with medullary fat and connective tissue. In the flat bones the compact tissue forms two limiting plates, separated by a layer of cancellous tissue (known in the skull as the diploë). In long bones the shaft consists of a tube of compact structure, surrounding a space which is normally filled with medulla, and known as the medullary canal; at each end it gradually merges into a larger mass of loose cancellous tissue, the interstices of which are similarly packed with vascular fatty medulla, which apparently performs the function not only of maintaining the nutrition of the bone, but also of elaborating the blood. Prolongations from the medulla extend into the Haversian canals, and are thence continuous with the periosteum, so that the mineral skeleton has incorporated within it a vascular fibro-cellular mass which permeates its whole structure.

The *vascular supply* of a bone is derived (*a*) from the nutrient artery which passes into the medullary space, and there breaks up into branches which ramify through the whole of the medullary tissue, and thence extend into the Haversian canals, and (*b*) from the periosteum, an exceedingly vascular ensheathing membrane, from which small vessels pass perpendicularly into the Haversian canals, and establish a communication between the two systems. These latter vessels are especially numerous and large close to the epiphyses. Large veins occur in the medullary and cancellous interior, and are frequently thrombosed in inflammatory mischief, if the thrombus becomes infected, and so disintegrated, pyæmia is very likely to ensue.

The *growth* of bone manifests itself in three different directions: (i.) It increases in length from the shaft side of the epiphyseal cartilage (or metaphysis), the epiphysis itself growing but little. In the upper limb the chief increase in length occurs at the shoulder and wrist, whilst in the leg it is mainly evident on either side of the knee-joint, and this in spite of the fact that the so-called nutrient arteries are directed away from these points. (ii.) Increase in breadth is produced by new formation under the periosteum (iii.) A bone increases in density by a new deposit of osseous tissue around the Haversian canals and cancellous spaces.

Finally, it must be pointed out that the development and growth of the skeleton are largely dependent on the healthy activity of the ductless glands; the pituitary and thyroid bodies certainly have considerable influence, and it is possible that the suprarenal, parathyroid, pineal, and thymus bodies are also not without effect Moreover, efficiency of the food-supply and the presence of sunlight or its equivalent, together with the provision of certain mineral salts, are necessary if healthy bone is to be laid down or maintained.

Inflammation of Bone.

Much needless confusion has arisen in connection with this subject owing to the undoubted difficulty of understanding the pathological phenomena, but also largely due to careless and contradictory nomenclature. The following considerations may assist in making the subject more clear:

1. All inflammatory affections of bony tissue might rightly be termed **osteitis,** but when the medullary cavity of a long bone is particularly affected the term **osteomyelitis** is substituted, as also sometimes when masses of cancellous tissue, as in the os calcis, or sheets of it, as in the diploe, become the seat of acute inflammation. The term **periostitis** applies to the ensheathing membrane; the vascular connection between it and the underlying bone explains why inflammation of this structure is always associated with a superficial or deep osteitis, and why in an acute infective inflammation of the medulla of a long bone the periosteum is also liable to be affected. **Epiphysitis** is the term applied to inflammatory affections of an epiphysis, which it must always be remembered has a vascular supply distinct from that of the diaphysis. As will be explained later, acute pyococcal affections do not often commence in the epiphysis, although it may be involved secondarily in an inflammation commencing in the neighbouring shaft; chronic diseases, *e.g.* tubercle and syphilis, do, however, involve epiphyses more frequently, though they are not limited to them.

2. In all inflammatory affections of bone the vascular structures are primarily involved, *i.e.* the medulla and its prolongations; the mineral element is only affected secondarily. The resulting phenomena, viz., hyperæmia, exudation and tissue change, differ in no wise from those seen elsewhere, save that the effects are modified by the limited space in which the vessels lie, and the resisting character of the surrounding bony tissue. Hence any *acute* inflammation involving compact bone, associated with vascular engorgement and rapid exudation, leads to *necrosis* from thrombosis, due to increased pressure within the unyielding bony canals. If, however, the bone involved is cancellous, or the process *subacute,* so that the tissue-liquefying properties of the exudation and the tissue-absorbing activity of the leucocytes can come into play, then *osteoporosis* or *rarefaction* of the bone follows, a condition sometimes termed *caries.* Not unfrequently, however, some of the more resistant fragments of the bony cancelli escape absorption and die *en bloc*, constituting a condition of *cario-necrosis.* On the other hand, if the inflammation is *chronic*, and due to causes other than tubercle or the pressure of tumours, then new formation occurs, and *osteosclerosis*, or condensation, is most likely to result. Tubercle in bones, as elsewhere, causes primary rarefaction of the tissue attacked, though sclerosis may be associated with or follow it.

3. It must always be remembered that necrosis, caries, and sclerosis of bone are **results** of inflammation, and not pathological processes or distinct diseases. Each of them may arise from many distinct causes. Thus **Necrosis** results from the following conditions: (*a*) From acute localized suppurative periostitis, the sequestrum or dead mass being then simply a superficial plate or flake of the compact exterior (Fig. 266), the process by which it is cast off being described as 'exfoliation'; (*b*) from acute infective osteomyelitis, the sequestrum often involving the whole thickness of the bone,

and invading more or less of the length of the diaphysis, if the condition is not early and efficiently treated (Figs. 270 and 271); (*c*) from acute or subacute infective osteitis of cancellous bone, the sequestra being small spiculated fragments of the bony cancelli which have escaped absorption; (*d*) from tuberculous disease of cancellous tissue, the sequestrum being light and porous, often infiltrated with curdy material, and rarely separated completely from surrounding parts (Fig. 277); (*e*) from syphilitic disease of cancellous or compact tissue, usually resulting from excessive sclerosis, or gummatous disease of the periosteum which has become septic (Fig. 280); (*f*) from the action of local irritants, *e.g.* mercury or phosphorus fumes gaining access to the interior of the teeth; (*g*) occasionally as a simple senile loss of nutrition, as in senile gangrene; and (*h*) a variety, described by Sir James Paget under the name of 'quiet necrosis,' occurs as a result of direct injury, the sequestrum separating without suppuration; it is one of the causes of loose bodies in joints, and especially the knee, following a blow on one of the condyles.

The presence of dead bone in a limb may be suspected when one or more sinuses are present, discharging pus or serum according to circumstances, with puffy granulations, pouting round the opening, and the underlying bone thick and enlarged. A probe passed down the sinus can usually be made to strike against the sequestrum, perhaps after passing through a casing of new bone, and its fixity or freedom may be demonstrated in this manner.

Caries, or, as it is sometimes called, *osteoporosis* or *rarefaction of bone*, is characterized by a soft and spongy state of the bone, which, if it can be reached, readily breaks down on pressure with a probe. It may result from the following conditions: (*a*) from acute or subacute infective inflammation of cancellous tissue; (*b*) from tuberculous affections of the cancellous tissue or periosteum; (*c*) from syphilitic disease of the medulla or of the under surface of the periosteum. The spongy vascular condition of the bone ends during the early stages of repair of a fracture is practically identical with this condition.

Pathologically, it is characterized by the replacement of the medulla by granulation tissue, which usually contains some large multi-nucleated cells, or *osteoclasts*, and these seem to be closely connected with the removal of the bone. The cancellous tissue becomes hollowed out to accommodate these granulations, and the osteoclasts are usually found occupying shallow depressions known as 'Howship's lacunæ.' In tuberculous and syphilitic lesions the bone corpuscles often undergo fatty degeneration.

Caries may occur with or without suppuration (*C. sicca* or *suppurativa*); sometimes the development of granulation tissue is excessive, as when it fungates into a joint (*C. fungosa*). Not unfrequently it is associated with necrosis, constituting a condition of *cario-necrosis* (or *C. necrotica*), as in infective inflammation of cancellous bone, minute spiculated sequestra being found in the discharge, whilst in tuberculous osteitis sequestra of larger size often occur. In fact,

caries and necrosis bear much the same relation to one another as ulceration and gangrene of the soft tissues.

If caries is recovered from, a condition of sclerosis usually follows, sometimes with loss of substance and deformity.

Sclerosis of bone (osteosclerosis) is invariably the result of some chronic inflammatory affection—*e.g.*, (*a*) chronic periostitis, whether simple or syphilitic; (*b*) chronic osteomyelitis, simple, tuberculous, or syphilitic; or (*c*) chronic osteitis of the compact bone, which is always secondary to one of the former. In all cases the condition is due to a slow formation of new bone within the Haversian canals or cancellous spaces, thus diminishing their lumen; in syphilis this may progress to such an extent as to lead to their total occlusion, and even to localized necrosis from lack of blood-supply, especially when sepsis has occurred. In tuberculous bones the sclerosed tissue is always at some distance from the focus of mischief, and may be looked on as Nature's attempt to limit the spread of the disease; it forms also the final tissue or bone-scar in the process of repair when a cure has been obtained by natural or surgical means.

Acute Inflammation of Bone.

1. **Acute Localized Periostitis** usually arises as a result of traumatism applied directly to the bone, with or without an open wound; it may also be determined by an extension of inflammatory mischief, as in an alveolar abscess.

Pathologically, the process consists of hyperæmia and of exudation into the periosteum, which becomes swollen, turgid, and thickened. This may be followed in due course by resolution, or may leave the bone thickened and in a condition of chronic inflammation; or suppuration may ensue, and with it usually a limited superficial necrosis.—In the last event pyogenic organisms of no great virulence find an entrance to the area of mischief, and probably in cases due to trauma through the abraded or injured skin; in other instances they may come from neighbouring foci of inflammation, or from the blood. The inflammatory process extends to the small vessels entering the bone from the under surface of the periosteum; these become dilated, thrombosed and strangled by the pressure of the exudation around them, and finally pulled out from the osseous canals by the tension of the subperiosteal effusion. Consequently, the vitality of the superficial layer of bone is impaired, if not destroyed, for an area corresponding almost exactly to that from which the periosteum has been stripped (Fig. 266, A).

As soon as tension has been relieved by the escape of the pus, repair commences. Where the mischief is slight and superficial, the involved bone may entirely recover, necrotic portions being absorbed, if the surrounding parts are sufficiently vascular. If the dead portion of bone is compact and more extensive, it will be separated from the subjacent living tisses by one of the processes already described (p. 114), whilst on the under surface of the stripped-up periosteum a casing of new bone develops, constitut-

ing an *involucrum* or sheath, at first spongy and cancellous in texture, but finally hard and sclerosed. In the centre of this new formation are found one or more openings or *cloacæ* through which the discharge escapes, and corresponding in position to the apertures in the periosteum and skin made for the exit of the pus (Fig. 266, B).

Clinically, the symptoms of acute localized periostitis consist in the ordinary phenomena of acute inflammation, the pain being of an intense aching character, worse at night, and increased by lowering the limb or by any kind of pressure. If a subcutaneous portion of bone is involved, a painful swelling develops, at first brawny in character, but when suppuration has occurred the centre softens, whilst the skin over it becomes red and œdematous. When an abscess has burst or been opened, bare bone is felt beneath the periosteum, and the greater part of this denuded structure usually dies, and must then be either absorbed or separated; in either case a sinus remains for a time, leading down through a cloaca in the involucrum to the sequestral cavity. From this either pus or serum will be discharged, according to whether a mixed infection of the wound has occurred or not. The time required for the separation of a portion of dead bone varies with its size and density, and with the vascularity of the surrounding parts; thus it may take over three months for a sequestrum to be set free from the shaft of the femur, whereas a period of five or six weeks will suffice if the ulna or radius is involved. That the sequestrum is free may be ascertained by moving it with a probe within the osseous cavity, or perhaps more surely by radiography.

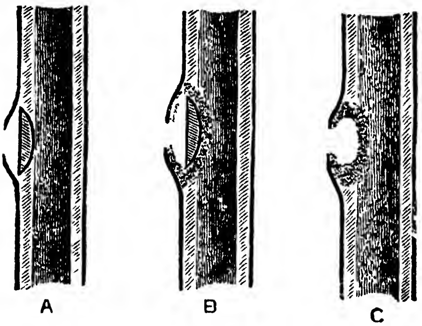


Fig. 266.—Superficial Necrosis resulting from a Localized Periostitis (Diagrammatic).

A represents the necrosed tissue lying in continuity with the surrounding living bone; the periosteum is stripped up from it, and has an opening through which the pus has been discharged. B shows a later stage in which the sequestrum is being separated by a process of rarefying osteitis in the immediately contiguous living bone, whilst an involucrum, or sheath of new bone, is formed from the under surface of the periosteum; a cloacal aperture remains in the involucrum for the escape of discharges. C shows the condition of affairs after the sequestrum has been removed.

Treatment.—Rest, elevation of the limb, and fomentations are usually relied on locally in the early stages, and favourable reports have been given as to the value of Bier's induced hyperæmia. If, however, the affection is not readily checked, and suppuration threatens or develops, a free aseptic incision down to the bone is the

best means of preventing or limiting necrosis. When necrosis has occurred, the parts must be carefully dressed and kept aseptic until the sequestrum is absorbed or set loose. In the latter case an incision is made over the involucrum, the periosteum stripped from it, one of the cloacæ enlarged, and the dead bone removed. The cavity will then rapidly fill up and heal by granulation.

2. **Acute Infective Osteomyelitis** (*syn.:* **Acute Necrosis, Acute Diffuse or Infective Periostitis, Acute Diaphysitis, Acute Panostitis**).—This disease usually occurs in children, and in boys more often than in girls (6 : 1), and not unfrequently follows one of the exanthemata —*e.g.*, measles or scarlet fever. It generally commences before the age of puberty, and is an affection of the gravest import; the multiplicity of names attached to it suggests quite accurately that its manifestations may be very diverse in character.

Pathology.—The patients are always in an unhealthy condition, with low germicidal powers, and may present one or many foci of local suppuration—*e.g.*, diseased teeth, or ulcerated gums or throats, or the evidence of lesions in the gastric or intestinal mucous membranes. An infected condition of the blood is almost always present before the attack. The causative organisms are usually *staphylococci* (78 per cent. Fraser*), but *pneumococci* were found in 14 per cent., and *streptococci* in 6 per cent.; these figures refer to 400 consecutive cases.

A slight injury in the shape of a strain or a wrench, which is often entirely overlooked, may suffice to determine by auto-infection an inflammatory process which rapidly spreads, until perhaps the whole bone is affected. The majority of the ligaments and not a few tendons are inserted into the epiphysis, and hence articular strain must be mainly felt in the juxta-epiphyseal region—*i.e.*, immediately beyond these insertions. It has been already mentioned that the traumatic separation of epiphyses is liable to be followed by suppuration, even in healthy children, and it is easy to understand that in an unhealthy child a very slight injury in the epiphyseal region may determine a similar process.

The disease almost always starts in the soft vascular tissue of the metaphysis (p. 634), but in a few instances (mainly amongst young adults) it may be preceded by a patch of localized periostitis, suggesting that an acute infection has supervened upon a subacute periosteal focus. The nature and extent of the inflammatory phenomena depend largely on the exact situation of the infective focus, the amount of resistance offered by surrounding tissues, and the virulence of the organisms. As in any other part of the body, the trouble is most likely to travel along the line of least resistance.

(1) If the process commences in the periphery of the juxta-epiphyseal region close to the periosteum, the line of least resistance will be towards that structure, and hence a *subperiosteal abscess* may form, whilst the central portions of the bone may escape almost

* Discussion on Acute Osteomyelitis, Section of Surgery, B M.A. meeting, 1924, *Lancet*, August 16.

entirely (Fig. 267). The size of this abscess varies, but considerable portions of the diaphysis may be denuded, resulting in extensive necrosis. It rarely spreads to the neighbouring joint, owing to the close bond of union which exists between the diaphyseal periosteum and the epiphyseal cartilage. In this form an early incision to let out the pus may suffice to prevent necrosis, or, at any rate, to limit it. The constitutional symptoms will be less severe than in other varieties; there is less likelihood of the development of pyæmia, and the toxic fever soon disappears after the removal of the pus. Subsequently the same course of events occurs as in the localized variety of acute periostitis—viz., an involucrum forms, perforated by one or more cloacæ, and the sequestrum in time separates.

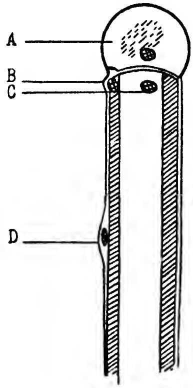


FIG 267.—ORIGINAL FOCI OF OSTEOMYELITIS.

A, In epiphysis; B, under periosteum at end of diaphysis; C, in metaphysis the usual site; D, under periosteum along shaft.

A good illustration of this type is to be found in the acute periostitis which affects the *lower end of the femur*. It almost always starts posteriorly, stripping the thin periosteum off the back of the bone as far as the bifurcation of the linea aspera. Its preference for this situation is due to the fact that strains upon the knee-joint are mainly felt when the limb is hyper-extended, and that such strain is directed to the posterior ligaments, and hence the posterior portion of the epiphyseal line is likely to suffer. Suppuration follows, and if not recognized and treated early, may burst through the thin periosteum and be widely diffused under the quadriceps. The involucrum in this affection is often defective behind.

(2) Should the process start in the centre of the metaphysis, it may spread in several directions, and the results vary considerably.

(*a*) The process may reach the periosteum first, and then the phenomena of a diffuse subperiosteal abscess, as indicated above, with the addition of the symptoms due to its deeper origin, will manifest themselves. This is, perhaps, the most usual course for the disease to take.

(*b*) If the infection extends along the medullary cavity, the most typical form of osteomyelitis ensues (Fig. 268). The medulla becomes intensely hyperæmic; the veins are thrombosed; localized foci of suppuration and gangrene appear; and in consequence of the increased pressure infective emboli are likely to be detached and pyæmia to follow. Even if the latter does not supervene, the general condition is profoundly affected by the absorption of toxins. Suppuration also occurs beneath the periosteum, although the amount

of pus may not be great at first; but the membrane is stripped up from the diaphysis, perhaps to such an extent as to involve the whole length and circumference of the shaft. Unless prompt measures are taken to limit the progress of the disease, necrosis is certain to follow, usually implicating the whole thickness of the diaphysis, and sometimes its whole length; in fact, the diaphysis is occasionally found lying loose in an abscess cavity, the two epiphyses having been detached. A similar result is sometimes due to the trouble

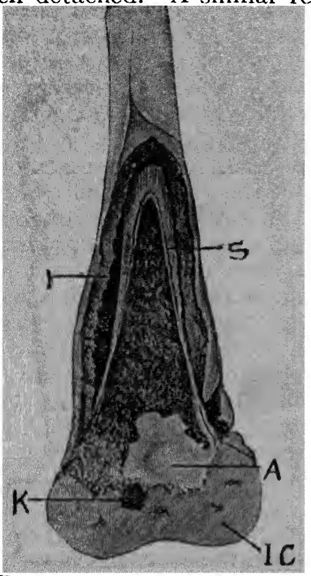


FIG. 268.—ACUTE OSTEOMYELITIS OF THE LOWER END OF THE FEMUR IN A CHILD OF NINE WEEKS. (AFTER LEXER.)

IC, Internal condyle; K, centre of ossification in epiphysis; A, abscess cavity in lower end of diaphysis; S, sequestrum; I, involucrum.

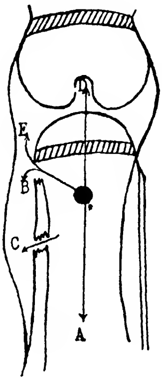


FIG. 269.—SPREAD OF OSTEOMYELITIS.

If the primary focus is in the metaphysis, spread may occur down the medulla (A), through the compact tissue near the diaphyseal cartilage under the periosteum (B), or into the joint (E), through the compact tissue of the diaphysis to form a subperiosteal abscess (C), or directly through the epiphysis into the joint (D).

starting at each end of the diaphysis. As a rule the epiphysis, even though detached, retains its normal position; but sometimes it becomes displaced, and then deformity results.

(c) Owing to the intimate connection between the periosteum of the diaphysis and the epiphyseal cartilage, the neighbouring joint usually escapes infection, although it is often the site of a sterile synovial effusion. Should, however, the epiphyseal line be within the joint, as in the hip, it must perforce become the seat of an acute infective arthritis as soon as the bacteria reach its periphery. The elbow-joint is similarly liable to suffer when bacteria attack the

upper end of the ulna, since the epiphysis is a mere flake of bone, and the greater part of the olecranon is derived from the shaft. Sometimes the junction cartilage is softened and destroyed by the organisms, so that the inflammation spreads through the epiphysis to the articular cartilage, which is eroded, and the joint opened. Occasionally the pus burrows along the soft tissues outside the bone, as along the biceps groove into the shoulder-joint.

FIG 270.—OSTEOMYELITIS OF THE TIBIA. (KING'S COLLEGE HOSPITAL MUSEUM.)

The sequestrum, composed of the eroded diaphysis, lies in a cavity surrounded by new bone, from which discharging sinuses open on to the skin. The knee-joint is distended with fluid.

(*d*) When the organisms are of a less virulent type, the process may be much more localized and subacute in nature, resulting in a limited central necrosis, or in a chronic abscess inside the bone (*Brodie's abscess*) if the part involved consists of a mass of cancellous tissue, as in the head of the tibia. A similar condition may affect certain epiphyses which occur away from joints, and some chronic abscesses in such situations as the great trochanter may be explained on these grounds. A chronic abscess of this nature may exist for many years, and cause much thickening of the surrounding bone from sclerosis (R.S., Fig. 26).

Another mild type is that known as **Albuminous or Serous Osteomyelitis.** It is usually seen in young children, and in not a few cases is due to the pneumococcus, but in others is caused by a staphylococcus of low virulence —*e.g.*, the *St. pyogenes albus*. The local and general phenomena are both less severe in character, and often clear up without the onset of necrosis. The swelling is brawny and œdematous, and even if pus forms, it is delayed and not accompanied by acute pain; neighbouring joints are likely to be distended with a serous exudation. The temperature does not run high, and there is but slight leucocytosis. Early operation does harm in these cases, which should be treated by rest and hot applications. If an abscess forms, it is opened and drained, and if necrosis occur, no attempt must be made to remove the sequestrum until it has separated.

An occasional result of a subacute non-suppurative osteomyelitis is bending of the affected bone, especially if the patient is able to put any pressure or weight on it.

(3) In the flat bones, such as the innominate, scapula, and those of the cranium, the cancellous tissue becomes filled with pus, and owing to the abundant supply of veins pyæmia is very likely to develop. Abscesses may form on both sides of the bone, and a large extent of necrosis may result. In the skull a subcranial abscess may develop, and possibly a true abscess in the brain.

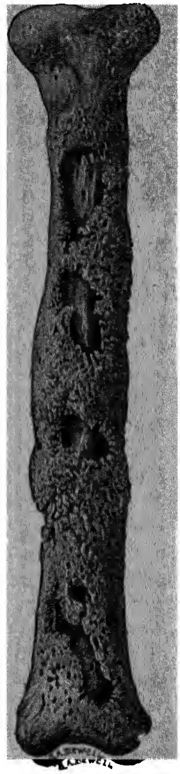


FIG. 271 —NECROSIS FOLLOWING ACUTE OSTEOMYELITIS. (FROM SPECIMEN IN COLLEGE OF SURGEONS' MUSEUM.)

The irregular new bone of the involucrum is well seen, and within it portions of the sequestrum.

Clinical History.—The disease usually commences abruptly with a rigor, followed by high fever and severe pain in the limb, which soon becomes swollen, brawny, and congested. It may be mistaken for an acute attack of rheumatism, although the fact that the inter-articular portion is affected, and not the joint, should prevent this error. The pain is of an extremely severe nature, so that the child screams whenever the limb or even the bed is touched.

Should the trouble be mainly limited to the periosteum, evidences of its being stripped off the bone and of the accumulation of pus beneath it soon show themselves. An abscess forms which may quickly transgress its periosteal boundary and burrow under fascial or muscular planes; its limitation to the diaphysis has been already explained; but, although the neighbouring joints may escape infection, they are very likely to suffer from a serous exudation, and subsequently some restriction of movement may be observed. Sooner or later the abscess bursts or is opened, giving exit to a larger or smaller quantity of pus, and the subjacent bone is found bare and apparently dead. Possibly the relief of tension may suffice in some cases to limit the mischief, the periosteum again becoming adherent to the bone, and a cure being established without extensive necrosis. More frequently a considerable portion of the shaft loses its vitality and has to be separated in the manner already described, whilst an involucrum forms around it from the periosteum (Figs. 270 and 271). If a mixed infection has not occurred, no

fever or bad constitutional symptoms need be expected during this later stage. Pathological fracture sometimes occurs as a complication if undue strain is placed on a limb which has been weakened by osteomyelitis.

When the medulla itself is more especially involved, the symptoms of pyæmia or of severe toxæmia become very prominent, and the child may die from this cause before the local mischief has been able to advance very considerably. The pain will continue to be of a severe character, although the patient's perceptions may be so blunted by the toxic condition that he becomes more or less unconscious. The swelling of the limb is not so great as in the former type, but the mischief may be very extensive, and although there is no great collection of pus beneath the periosteum, yet it may be stripped up along the whole length of the shaft, which may even be detached from the epiphysis at each end. Should the child not die of toxæmia, extensive destruction of bone is certain to result.

In infants and very young children, especially if the subjects of inherited syphilis, the disease early spreads through the non-vascular cartilage of the epiphysis to the neighbouring joint, and the symptoms of acute suppurative arthritis supervene. The head of the humerus and the upper and lower ends of the femur are the parts most commonly involved in this way. In some of these cases the ligaments are so seriously weakened and relaxed that a loose flail-joint results, and pathological dislocation may result.

In the **milder types of osteomyelitis,** the patients complain of severe pain in one of the bones (one form of 'growing pain'), and this may be attended by some degree of fever and of local disability. The symptoms may quiet down after a time and no harm result, but in some cases the growth of the bone will be checked or entirely stopped. In other patients a subacute or chronic abscess may form and perhaps come to the surface at a later date, and on opening it a sinus is found leading to the interior of the bone, in which a sequestrum of cancellous tissue is found. In such a case the surrounding bone may at first be rarefied to such an extent as to bend under the weight of the body, but in the later stages is certain to be much thickened and very sclerosed. The patient will have suffered from repeated attacks of pain in the bone, which may be felt to be thickened, and in the case of an encysted abscess a spot of localized tenderness can usually be detected.

Schlatter's Disease is probably of this nature, involving the upper end of the tibia in young people. It is probably due to a slight injury directed to the lower tongue-shaped prolongation of the upper epiphysis, which forms the tubercle of the tibia, and is followed by a subacute inflammation of the epiphyseal line, which does not result in suppuration. The child complains of a tender swelling in this region without any affection of the joint, and walks with a limp. Radiographic examination suggests displacement forwards of the epiphysis, but there is no mobility. Treatment consists in rest and protection of the part from injury, and in time the condition gets well.

Köhler's Disease is a similar affection limited to the scaphoid bone (tarsal), which is somewhat enlarged and sensitive to pressure. In the X-ray picture (R.S., Fig. 31) the bone or its ossified centre appears to be abnormally dense,

shortened antero-posteriorly, and correspondingly broader. The condition usually appears in adolescents, and is likely to be mistaken for static flat-foot; it causes a limp. It may be due to injury, but the symptoms are transitory, and a return to a practically normal condition under the protection assured by a flat-foot support is the rule in a year or more.

Kienböck's Disease also comes under this heading: it is a quiet sclerosing osteitis of the carpal semilunar, and the X-ray appearance is very similar to that of the tarsal scaphoid in Kohler's disease. There can be no doubt that in a certain number of cases traumatism plays an important part, and it sometimes follows a typical crush fracture of the bone.*

Apophysitis of the Os Calcis is a condition similar to Schlatter's disease. There is an epiphysis over the tuberosity of the os calcis which commences to ossify between the seventh and ninth years, and fuses with the bone between the sixteenth and twentieth years. Slight injury may cause enlargement of the heel, which on X-ray examination may show apophysitis. The epiphysis may be fragmented, and the clear area between the epiphysis and the body of the os calcis may be broader than normal (R.S., Fig. 32). On each side of this area the bone is irregular, as if ossification had been interfered with. Treatment consists in rest of the part, and protection from further injury.

The **Prognosis** of the acute form is always grave. Life may be threatened by pyæmia or toxæmia in the early stages, whilst later hectic fever, amyloid disease, and exhaustion, may terminate the case if a mixed infection has occurred.

The utility of the limb may be unimpaired if the disease has not been too extensive, and if prompt treatment has been adopted; but if life is threatened by toxæmia, or if neighbouring joints suppurate, or if the osteogenetic powers of the periosteum have been destroyed by the acuteness of the process, amputation may be required.

Treatment.—Prompt surgical interference must be adopted in order, if possible, to cut short the malady. As soon as the local pain and high fever give evidence that this affection is present, a free incision should be made in the long axis of the limb through the periosteum, whether pus can be detected or not. The surgeon will then proceed to investigate carefully the condition of the bones by inspection and the use of the finger and probe. As a rule, he will find himself in the neighbourhood of the epiphyseal cartilage, and if the case has been taken in hand early, it is possible that the mischief will be quite limited; all that is then required is to scrape or gouge away the softened and hyperæmic bone at the end of the diaphysis, together with any necrotic tissue which may be present, taking the greatest care not to perforate the epiphyseal cartilage. The cavity thus formed is drained or packed with gauze, infiltrated with Bipp, and in all probability recovery will rapidly ensue.

If the case has gone further, the periosteum will be found stripped from the bone for a varying distance, although but little pus may be present beneath it. Under these circumstances it is always necessary to open up by trephine, gouge, drill, or cutting-pliers the medullary canal, so as to allow pus to escape and the hyperæmic and gangrenous fatty tissue contained therein to be scraped out. If this proceeding involves a considerable portion of the shaft, it may be possible to leave bridges of compact tissue here and there,

* H. A. T. Fairbank, *Proc. Roy. Soc. Med.*, Orthopædic Section, May, 1929.

scraping out the medullary cavity beneath them, and disinfecting the cavity by Carrel's method. When grave constitutional phenomena are present, associated with loosening of the epiphysis, it may be necessary to amputate in order to prevent death from toxæmia.

If the periosteum has been extensively involved, a large amount of bone, possibly the whole diaphysis, is denuded, and perhaps both epiphyses are loosened. The dead diaphysis should be removed at once if the leg or forearm is involved, as there is always a second bone to maintain the length of the limb; but for the femur and humerus its removal should be delayed—immediate removal would lead to hopeless shortening and crippling.

When it is probable that the medulla is not much involved, the pus is given a free exit through an incision, the cavity is irrigated, and the stripped-up periosteum allowed to fall back upon the bone, and regain adhesions to it, if possible. Drainage is provided for, strict asepsis maintained, and the discharge soon becomes merely serous. A portion of the bone dies, and during its separation becomes encased in a newly-formed involucrum.

When the sequestrum is free—that is, in about two or three months—*sequestrotomy* will be required; it consists in reflecting the periosteum from the new casing, and in enlarging or uniting one or more of the cloacæ, so as to allow the sequestrum to be withdrawn. In some cases it is desirable to approach the sequestral cavity by some safer route than that suggested by the sinus; *e.g.*, when the necrosis involves the lower end of the femur, it is often wise to cut down on it from the outer side, although the sinuses are central. It is not always easy to remove the sequestrum *en bloc*, and it may be necessary to divide it; the greatest care must be taken not to leave any portion behind, as the wound cannot heal in this case. The empty cavity should be irrigated and disinfected, and may be left to close by granulation, or be packed with gauze, but healing is often very slow and some method as indicated below is required. See also p. 556. Occasionally removal of the sequestrum is almost impracticable, and under such circumstances *amputation* may be preferable. This summary proceeding may also be needed in the course of this disease on account of pyæmia, defective repair, exhaustion from chronic toxæmia, or suppuration in a neighbouring joint.

Osteomyelitis of the flat bones involves opening freely into the cancellous tissue by gouge or trephine, and scraping away all the bone which is diseased or infiltrated with pus. In the cranium the inner table should not be perforated unless the surgeon suspects the existence of subcranial suppuration.

The **closure of a cavity left by the removal of a sequestrum** (or of a growth from the interior of a bone or of a tuberculous focus) is not always simple, inasmuch as the walls consist of osseous tissue which is not too well supplied with blood, and which becomes less vascular as the condition becomes more chronic. The shape of the cavity also influences the rapidity of the healing process.

The ideal cavity to leave after the removal of a sequestrum is a shallow crater, over the margins of which the soft tissues can be adapted. After removal of the sequestrum and of that portion of the involucrum which overhangs the cavity, bleeding is checked by the use of swabs wrung out of hot saline; the cavity is then mopped over with absolute alcohol or ether, carefully 'bipped,' and then the soft tissues are drawn together over the hollow so as to close it entirely, or the wound is packed with bipped gauze, which may usually be left *in situ* for ten days. In some cases it may be possible to detach one or both bony sides of the cavity and press them inwards so as to reduce its size. Bone grafts have also been utilized, *e.g.* a phalanx clipped up into small fragments, and fat grafts, but the best method of filling up such a cavity is by means of a pedunculated muscle graft turned in from the neighbourhood, *e.g.* from the gastrocnemius or soleus for cavities in the tibia.

Sinuses penetrating through the whole thickness of a bone are most difficult to heal, inasmuch as the bony walls cannot fall together. In such cases the total removal of one side of the tunnel may suffice to permit the soft tissues to fall in and close up the space; but if this is not possible, then the cavity must be cleared and cleansed, and some grafting process (bone or muscle) adopted.

FIG. 272.—TUBULAR OR CONICAL SEQUESTRUM FROM ACUTE OSTEOMYELITIS OF FEMUR AFTER AMPUTATION.

3. The **Acute Traumatic Osteomyelitis** which arises as a result of infection from without —*e.g.*, in cases of compound fractures, and after amputation, excision, or even osteotomy—requires a separate description. The clinical history of a case involving the shaft of a long bone is as follows: The patient during an attack of septic traumatic fever due to an injury or operation has one or more rigors, which suggest the existence of pyæmia, and is suddenly seized with severe pain in the limb, which becomes intensely sensitive. On examining the wound, the soft parts are found to be unhealthy and infiltrated, the lower end of the bone is bare and yellow, and from the interior a stinking mass of gangrenous medullary tissue sometimes protrudes. Should early and efficient treatment not be undertaken, the patient runs a considerable risk of succumbing to acute pyæmia or toxæmia, whilst a varying amount of the interior of the bone dies (*central or tubular necrosis*), and a small segment of its whole thickness below, so that the sequestrum which ultimately separates is annular and conical (Fig. 272). Should the patient survive, the necrotic tissue

gradually separates, and during this process a mass of new bone is formed from the under surface of the periosteum, so that the shaft becomes much thickened externally.

Treatment.—The wound is thoroughly opened up as early as possible, flushed out, and the sloughing medullary tissue scraped from the interior of the bone, which is subsequently disinfected with pure carbolic acid, a drainage wick of gauze or rubber glove being placed in it for a few days. A certain amount of necrosis follows, but without high fever or toxæmia. Should this treatment fail, amputation will be required, or complete excision of the affected segment of bone.

4. **Acute Osteomyelitis of Cancellous Tissue** develops after an infected wound of the short bones, or of the cancellous extremities of long bones; it may also be caused primarily by auto-infection, or may be secondary to acute infective arthritis, or the result of a pyæmic embolus. The local and general phenomena are very similar to those detailed above, except that no large sequestra are formed, the dead bone coming away in spicules (one form of *caries necrotica*), whilst the pain and fever are less severe, and there is less likelihood of the development of pyæmia. *Treatment* consists in opening up the infected area and removing all diseased tissue; the cavity thus formed must be efficiently drained, if need be, through a counter-opening, and may advisably be packed with 'bipped' gauze. The general health must be attended to, and care taken to prevent or limit deformity.

5. **Typhoid Osteitis.**—Affections of the osseous system are not uncommon in typhoid fever, and usually come on during the early stages of convalescence. The tibia and ribs are most often affected, and in a large percentage of cases typhoid bacilli, with or without pyogenic cocci, will be found. The trouble commences either as a periostitis or osteomyelitis, subacute in character, often improving temporarily, and then relapsing; it is curious to note how long the organisms may lie latent in the tissues before causing an abscess. In time an abscess usually develops, together with some amount of necrosis or caries. Sometimes an abscess within the bone communicates through a small sinus with one beneath the periosteum, constituting the so-called 'collar-stud' abscess. On its first appearance the affected limb should be elevated and fomented, and frequently the more acute symptoms will yield, but the part often remains enlarged, swollen, and tender, and exacerbations of pain are not unlikely to develop from time to time, culminating sooner or later in abscess formation. When suppuration has occurred, the parts must be freely incised, diseased bone removed, granulation tissue scraped away, and the parts disinfected with 'bipp.' The wounds are usually found to be extremely chronic and indolent, and may require scraping several times.

Chronic Inflammation of Bone.

Chronic Osteo-periostitis is a chronic inflammatory condition of the bone, which results in overgrowth, thickening, and condensation.

Varieties.—(*a*) It may arise as a *localized* chronic periostitis, traumatic, toxic, rheumatic, or syphilitic in origin, or due to the close proximity of a chronic ulcer. It is characterized by a formation of new bone beneath the periosteum, the so-called *node* (Fig. 273), the cancelli of which are arranged at right angles to the surface. At first this new material is soft and spongy, but it rapidly becomes hard and sclerosed,

and a similar condition affects the subjacent compact structure, which is thickened and indurated by a new formation around the Haversian canals. If the irritation persists, as in the case of a chronic ulcer, this condition may run on into the following variety.

(*b*) The *diffuse* form of chronic osteo-periostitis usually originates in some deep-seated or central affection, tuberculous or syphilitic in nature, and often involves the whole bone, although sometimes limited to one or other end. If tuberculous, there may be a small chronic abscess or some central necrosis, and around this the bone becomes thick and indurated. In the later stages a considerable new formation may occur beneath the periosteum, and the medullary canal becomes encroached on or obliterated (Fig. 276). If syphilitic in origin, it may be due to a central gumma, or to a general condition of sclerosis, developing without any localized focus.

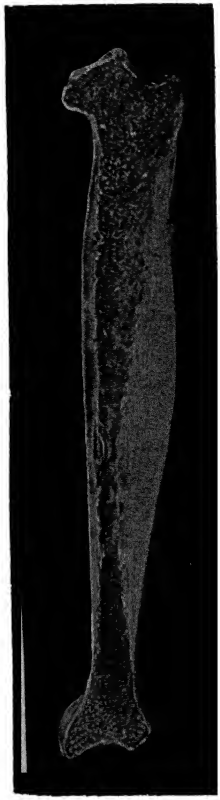


FIG. 273.—CHRONIC OSTEO-PERIOSTITIS OF TIBIA, SHOWING FUSIFORM SWELLING ON THE FRONT OF THE BONE, CONSISTING OF DENSE OSSEOUS TISSUE, AND THE MEDULLARY CAVITY ENCROACHED UPON. (MUSEUM OF ROYAL COLLEGE OF SURGEONS.)

The **Symptoms** consist of deep aching pain in the limb, worse in bed, with perhaps tenderness over some particular spot, especially in cases where an encysted abscess exists in the head of a bone, such as the tibia. On examination the bone is felt to be thickened, and its surface more or less nodulated. If the disease is limited and superficial, a distinct node may be felt, consisting of a hard, fusiform, and tender swelling. Where the enlargement is more general, there is less tenderness, though the pain is constant.

The **Diagnosis** of such cases is not always easy, the enlargement of the bone being sometimes mistaken for the *early stage of a malignant tumour*. The rate of growth will be of little assistance, since it is very variable; but a tumour may have more defined limits, and its tension is often not the same throughout. Radiography is valuable in this direction, since in simple chronic periostitis the bone is solid and throws a continuous and well-defined shadow, while in malignant disease a certain amount of soft tissue is always present, either centrally or peripherally, easily penetrated by the rays, and hence leaving gaps in the shadow. If, in spite of such assistance, the case is still doubtful, an exploratory incision will be required.

The **Treatment** consists in resting the limb, applying counter-

irritation (*e.g.*, iodine paint or the actual cautery), and giving iodide of potassium internally. If relief is not thereby obtained, it will be necessary to cut down over the whole length of the thickened bone through the periosteum, which is stripped aside, and if merely a nodular enlargement is present, to chisel away the new formation. When the whole thickness of the bone is involved, a gutter or trench must be made by gouge and mallet, extending into the medullary cavity, and its length corresponding to the enlargement. The soft parts are loosely drawn together; the hollow will fill with blood-clot, which is allowed to organize. If enough bone has been removed, most satisfactory results follow; but in some aggravated conditions which have lasted for many years amputation is required.

Tuberculous Diseases of Bone.

Bone may be affected in many ways by tubercle, the process starting either beneath the periosteum or more commonly in the cancellous tissue of the interior. The infection is obviously secondary to disease elsewhere, and the bronchial or mesenteric glands are the commonest source of its origin. The osseous affection is often insidious in its onset and chronic in its course; it has a considerable tendency to involve neighbouring joints and to give rise to suppuration.

1. In **Tuberculous Periostitis** a specific infiltration of the periosteum is met with, consisting of a deposit, partly in that membrane and partly under it, of pulpy granulation tissue containing the characteristic miliary tubercles, which are chiefly developed around the vessels passing from the periosteum into the bone. As in tuberculous disease elsewhere, caseation and suppuration are likely to follow, leading to the formation of abscesses, which are primarily subperiosteal and filled with curdy pus; these in time find their way to the surface, either directly or by more or less tortuous channels, and leave sinuses, extending down to the diseased area. The effect on the bone may be insignificant if the part affected is dense, consisting merely in some slight superficial erosion; occasionally, however, the disease may spread along the periosteum, and involve a neighbouring epiphysis or joint. If the compact layer is *thin*, as in the sternum, ribs, or bodies of the vertebræ, the underlying cancellous tissue is almost certain to be secondarily affected, and caries will result.

Clinical History.—In a superficial bone a doughy or pulpy swelling forms, which is slightly tender on pressure. It takes weeks or months to develop, and on radiography the underlying osseous tissue may appear quite normal in texture. In the later stages, when caseation or suppuration is present, the swelling often becomes more defined and somewhat resembles an ordinary node, but is more irregular in shape, of somewhat unequal consistency, and on firm pressure small portions may be felt to give way. If an abscess forms, the skin becomes reddened, the swelling is elastic to the touch, and the pain greater, but it diminishes as soon as tension is relieved

by discharge of the pus. A sinus, however, forms, and a probe passed down impinges on soft carious bone. The admission of pyogenic infection increases the trouble.

Treatment.—In the early stages, constitutional treatment may suffice, together with rest and carefully-adjusted pressure, as by strapping with Scott's dressing, or Bier's induced hyperæmia, where applicable. The condition, however, demands incision if a neighbouring joint is threatened, or when suppuration has occurred. Free removal of all the granulation tissue and softened bone with a Volkmann's spoon is required, followed by disinfection of the cavity with alcohol and 'bipp,' and, if possible, closure of the wound without drainage. If a rib is involved, it is wiser to remove entirely the affected portion of bone.

2. **Tuberculous Osteitis** arises in cancellous tissue, and usually in the epiphyses, or under the articular cartilage; occasionally it develops in the medullary cavity as a chronic osteomyelitis.

Pathology.—The tubercle bacilli are deposited in the interior of the bone, which may have previously sustained some mild injury. The outcome of this is the transformation of the normal medulla into pulpy granulation tissue containing tubercles, the bony cancelli becoming meanwhile eroded and rarefied, and the bone corpuscles undergoing fatty degeneration (*vide* Caries, p. 636). Sequestra occasionally form, but more often in adults than in children, owing to the greater density of the bone in the former. They are due to a cutting-off of the blood-supply of a definite portion of the bony tissue, either as a result of tuberculous endarteritis, or from early caseation within the cancelli of the whole of the granulation tissue. The sequestra are soft and friable, usually yellowish-white in colour from the presence of the caseating tissue in their substance, and are seldom separated completely from the surrounding bone. When the tuberculous disease does not involve the whole bone, the nearest healthy tissue may become sclerosed, and thus one not unfrequently finds a central sequestrum surrounded by rarefied bone, which in turn is enclosed by a zone of sclerosed tissue. Very frequently the disease extends from the interior of the bone either to a neighbouring joint or to the periosteum, or possibly to adjacent tendon sheaths, and external abscesses are then likely to develop. The admission of pyococci leads to increasing rapidity of the destructive process, and minute spiculated sequestra often come away in the discharge. Radiography is a useful adjunct in estimating the amount of disease present, since the affected bone offers little or no resistance to the passage of X rays.

(*a*) The *short bones of the hands and feet* are very liable to this condition in weakly children whose general health has been deteriorated by living in unhealthy conditions or depressed by one of the exanthemata. Some slight injury may determine the onset of the attack, which frequently involves several bones simultaneously. When the phalanges are involved, the disease is known as **Tuberculous Dactylitis.**

Clinical History.—The affected segment of the finger becomes slowly enlarged, bulbous, and painful, the pain being, however, slight in amount, though sometimes worse at night. At first the finger looks white, and the skin is smooth and shiny; but after a time one spot rapidly increases in size, becoming red and tender, and finally an abscess forms, which bursts or is opened, leaving a sinus, down which a probe can be passed into the carious interior of the bone. Occasionally contiguous joints are involved in this process, whilst the tendon sheaths are also liable to be affected; a large portion of the swelling is often due to periosteal infiltration (Fig. 274). In some cases the bone appears to be expanded, but the term *expansion* is scarcely correct, inasmuch as the enlargement is due to absorption on the inner aspect, whilst there is a new formation of bone under the periosteum. Natural cure without suppuration occurs when the child is placed under suitable hygienic conditions, but even then the growth of the phalanx may be hindered, and the finger remains shortened.

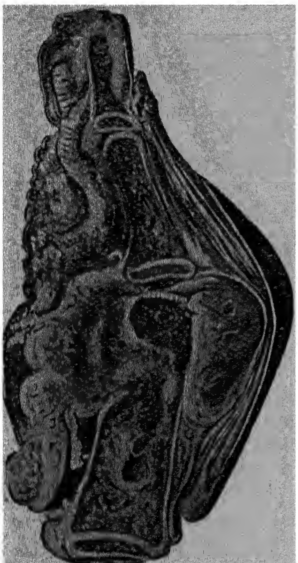


FIG. 274.—TUBERCULOUS DACTYLITIS. (ROYAL COLLEGE OF SURGEONS' MUSEUM.)

The disease started in the proximal phalanx, and has spread to the periosteum and flexor tendon sheath, whilst the first interphalangeal joint is becoming invaded.

The **Treatment** of tuberculous dactylitis must be conducted along the lines laid down for tuberculosis generally on p. 194. The child is transferred to some healthy place where treatment of a sanatorium type is possible, and there it must remain, perhaps for years, until the trouble comes to an end; educational facilities must therefore be included in the programme. The local treatment consists in putting the hand to rest on a splint, and possibly applying Scott's dressing to the affected finger. There is but little call for operative treatment under such circumstances. If an abscess forms, it should be aspirated at an early date, so as to avoid the risk of sinus formation. In the worst cases where pyococcal troubles are also present, amputation may be required.

(*b*) Any of the *bones of the tarsus* may be involved in exactly the same manner, the clinical history and treatment being identical, although articular lesions are more common than when the disease is limited to the phalanges. The affected portion of the foot becomes swollen and shiny, since the overlying periosteum is often involved in the process; and it is sometimes difficult to determine

whether the lesion is limited to the bones or also involves the joints. In the early stages one part of the foot may be more swollen than another, according to the location of the trouble. The os calcis is most often affected, and afterwards, in order of frequency, come the first metatarsal, astragalus (the head), and scaphoid. When it starts in the astragalus, the swelling occurs below the level of the ankle-joint in front of or behind the malleoli, whilst pressure over the head of the bone gives rise to pain. The foot is usually in a position of equinus, but not to such a marked degree as when the ankle-joint itself is affected; the subastragaloid movements (inversion and eversion, abduction and adduction) are also considerably limited, or may be absent. An examination of the accompanying illustration (Fig. 275) will explain the fact that tuberculous disease

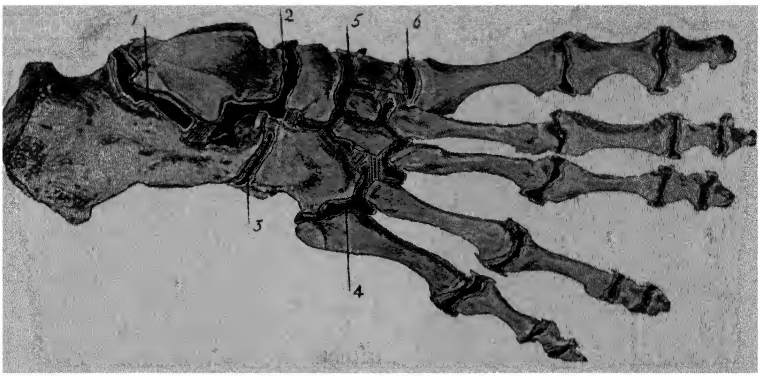


FIG. 275.—ARRANGEMENT OF SYNOVIAL MEMBRANES OF FOOT.

1, Posterior calcaneo-astragaloid, behind the interosseus ligament; 2, anterior calcaneo-astragaloid and astragalo-scaphoid; 3, calcaneo-cuboid; 4, cubo-metatarsal; 5, the large common sac between scaphoid and cuneiform, between the three cuneiform bones, and between the cuneiform and second and third metatarsals, 6, between the internal cuneiform and first metatarsal.

starting in the astragalus is very likely to involve the ankle-joint, or to spread to the os calcis or scaphoid. Disease of the os calcis leads to more limited swelling of the back of the foot on one or both sides of the heel; the movements of the ankle will not be impaired, although walking is painful, and hence the patient limps, treading only on the toes. Further forwards, tuberculous disease is most likely to start in or around the scaphoid, the bulbous swelling of the foot being then shifted anteriorly, and the movements of the ankle remaining unimpaired. Owing to the arrangement of the synovial membranes, the prognosis is much worse when the disease attacks the inner half of the foot, comprising the astragalus, scaphoid, cuneiform, and three inner metatarsal bones, than when it affects the outer segment, consisting of the cuboid and two outer

metatarsals, which are excluded from the general synovial membrane, and are thus more amenable to treatment.

The **Treatment** consists in the usual local and constitutional measures adopted in tuberculous disease (p. 194). In the early stages the foot and ankle are immobilized, and preferably in plaster of Paris or water-glass, and the foot is not allowed to be used until all pain has ceased. Older patients are fitted with a Thomas's knee-splint and a patten, and allowed to get about on crutches.

Should the disease persist, or suppuration recur after aspiration, operation may be required. If the *os calcis* alone is involved, it will suffice to open it from one or both sides, to scrape out and disinfect its interior, with subsequent closure of the wound. If the disease mainly affects the *astragalus*, it may suffice to remove it entirely, neighbouring articulations being curetted; but probably the disease will have spread so far that Syme's amputation will be required. Disease of the *cuboid* and outer half of the foot in front of the os calcis can often be dealt with efficiently by scraping, but when the common synovial membrane on the *inner side* is involved, and hygienic treatment fails, amputation will probably be needed.

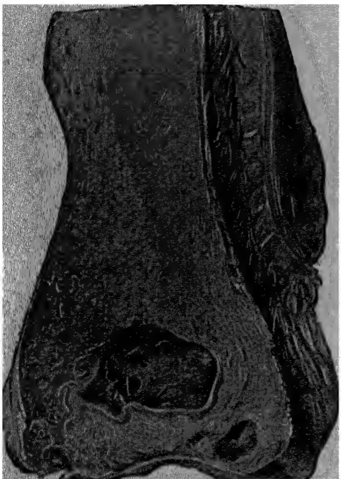


FIG. 270.—CHRONIC ABSCESS IN THE LOWER END OF THE TIBIA. (KING'S COLLEGE HOSPITAL MUSEUM.)

(*c*) If the tuberculous disease affects *the ends of long bones*, it most commonly starts in the epiphysis, or under the articular cartilage, though sometimes on the shaft side of the epiphyseal cartilage. The changes already described take place, and lead to early destruction of the latter cartilage, so that the adjacent parts of both epiphysis and diaphysis become involved (**tuberculous epiphysitis**). The general signs are similar to those present when the smaller bones are affected, but the results produced may vary considerably. (i.) In the earlier cases where efficient treatment is adopted, the tuberculous tissue may be totally absorbed, and the process thus comes to an end, though the affection of the epiphyseal cartilage may lead to subsequent impairment of growth. (ii.) In others it may be circumscribed by the bone becoming sclerosed around a caseating focus, and then, if suppuration ensues, a *deep abscess in the end of the bone* may be produced (Fig. 276). Such is rarely of large size, containing at most 1 or 2 drachms of curdy pus, and is lined by a definite pyogenic membrane of the usual tuberculous type. The effects produced by this condition are

similar to those of any chronic inflammation of bone, viz., a deep aching or boring pain, worse at night, together with enlargement of the affected bone, whilst one spot is often very tender on palpation. If it has existed for any length of time, the whole shaft may become enlarged as a result of chronic osteo-periostitis. (iii.) The disease may burrow along the epiphyseal line, and find its way into the neighbouring joint, if the epiphysis is intra-articular, as in the hip; but if the epiphyseal cartilage is placed beyond the limits of the capsule, a subperiosteal extra-articular abscess will develop

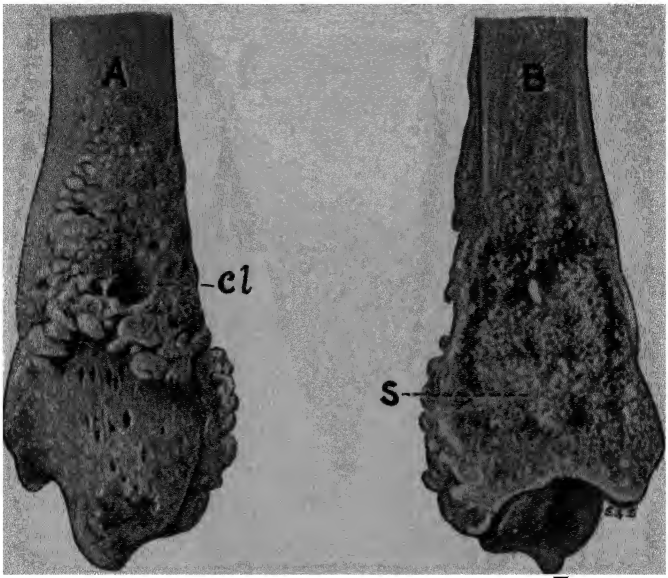


FIG. 277.—LOWER END OF TIBIA AFFECTED WITH TUBERCULOUS DISEASE (KING'S COLLEGE HOSPITAL MUSEUM.)

In A, a subperiosteal deposit of new bone is seen surrounding an opening (cl), which leads into the interior of the bone; in B, the interior of the same bone is seen, and shows a sequestrum (S) just above the epiphyseal line. The ankle-joint is healthy.

(Fig. 277). Should the disease spread equally in all directions, the epiphysis may actually be separated. (iv.) A more common result is for the whole or part of the cancellous tissue of the epiphysis to become involved, and the joint to be secondarily affected with tuberculous arthritis, either by perforation, erosion, or necrosis of the articular cartilage, or by extension to the synovial membrane around its margins. (v.) The process may sometimes extend upwards along the medulla into the shaft, causing a diffuse osteo-periostitis, with or without a medullary abscess (Fig. 278).

The **Treatment** of tuberculous epiphysitis is conducted by absolute immobilization locally, and the use of the hygienic and general measures indicated at p. 194, and it is most unusual for cases not to respond favourably, if they have been taken in time. Local helio-therapy is most valuable, or if sunlight is absent exposure to the ultra-violet rays of an arc lamp, or even radio-therapy should be used. The surgeon must not be tempted to find a short cut for these cases by operative measures, but must educate himself in the salutary virtue of patience. Of course, during the whole period of

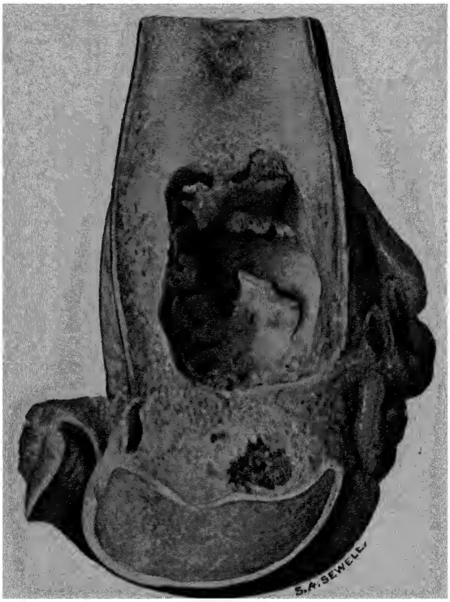


FIG. 278.—LOCALIZED ABSCESS IN THE LOWER END OF THE FEMUR EXTENDING FROM THE EPIPHYSEAL LINE UPWARDS INTO THE MEDULLA. (FROM SPECIMEN IN THE COLLEGE OF SURGEONS' MUSEUM.)

treatment, care is taken to prevent contraction of neighbouring joints or deformity. Only rarely is it necessary to open up the epiphysis and clear out the diseased tissue. When a chronic abscess in the end of the bone is diagnosed as a result of the symptoms present or of the radiographic examination, operation is desirable, and consists in applying a trephine over the painful spot in the bone, and if the cavity is not directly opened, the bone should be drilled in various directions to localize the pus.

(*d*) The *medullary canal* of the shaft of a long bone sometimes becomes the seat of tuberculous disease; this, as also the abscess of

bone described above, is more common in adults than in children. The part thus affected becomes carious, with or without the formation of sequestra or pus; but the most marked feature of this deep-seated central trouble is that the whole bone passes into a state of chronic inflammation, which we have described, as well as the treatment necessary for it, under the title of chronic diffuse osteo-periostitis (p. 648).

For tuberculous osteomyelitis of ribs, see p. 678.

Syphilitic Diseases of Bone.

In the **Secondary Stage** flying pains about the bones (sometimes termed *osteocopic*) are often complained of; they are, however, of but little importance, and disappear rapidly as the patient gets under the influence of treatment. In the late secondary or early tertiary periods, a *periosteal node* is often met with, as a result of chronic periostitis. It usually affects only one bone, and most commonly the tibia, and consists of infiltration and thickening of the periosteum, which may entirely disappear or be followed by a formation of new bone, which is at first spongy and soft, but after a while becomes hard and sclerosed. When this has once occurred, absorption of the newly-formed bone does not readily follow, even under treatment, the part remaining permanently thickened. It is recognized clinically as a fusiform swelling, a little tender on pressure, and the seat of deep aching pain, usually worse at night. It must be understood that the pain is not so much associated with the onset of night as with the increased warmth of the limbs when in bed; indeed, patients with syphilitic tibiæ frequently sleep with their legs exposed. Night-watchmen and others, on the contrary, complain of pain during the day, when they take their rest. Suppuration does not occur, and constitutional rather than local treatment is required.

In the **Tertiary Period** the bones may participate in the changes which involve any and every tissue of the body. The following lesions are described. but are nowadays rarely seen.

(*a*) The formation of *subperiosteal gummata*, either localized or diffuse, probably resulting in *caries* of the subjacent bone; if the affection is limited, only a small portion may be thus involved; but where it is widely diffused, an extensive surface of the bone may become eroded and irregular. This process is sometimes accompanied by a development of new bone under the adjacent periosteum, and even by sclerosis and necrosis. The calvarium is the part most frequently involved, and as but little new bone forms in this situation, the skull often presents a curiously pitted or worm-eaten appearance (Fig. 279). The overlying scalp is usually invaded and destroyed by the gummatous process, permitting the entrance of pyococci; deep and sometimes extensive wounds result, discharging foul pus, and at the bottom of which bare and even dead bone may be felt.

(*b*) At the same time a condition of *sclerosis* may develop in the underlying or surrounding parts, and this to such a degree as seriously to compress and constrict the vessels in the Haversian canals. Moreover, an obliterative endarteritis is almost always present, and these factors, combined with the separation of the periosteum and the influence of the mercury administered for therapeutic purposes, so interfere with the vitality of the bone that, should pyococci be admitted, necrosis is almost certain to ensue.

The effects produced vary considerably in different cases, and especially with the situation. When the *calvarium* is attacked, pyogenic infection often supervenes, owing to the thinness of the scalp and the depth to which the hair follicles penetrate, and consequently necrosis is common. The process in such a case as is represented in Fig. 280 is probably as follows: The pericranium corresponding to the necrotic area becomes gummatous, and at the same time the subjacent bone undergoes sclerosis. Sooner or later the gummata burst or are opened; pyogenic infection occurs,

FIG. 279 —SYPHILITIC CARIES OF SKULL FROM DIFFUSE GUMMATOUS DISEASE (FROM KING'S COLLEGE HOSPITAL MUSEUM.)

and the scalp tissues are stripped off the calvarium to the limits of the disease, necrosis resulting in the sclerosed area of bone. A line of rarefaction subsequently forms around the sequestrum in consequence of Nature's attempts to separate it. The later stages of the disease are marked by extreme chronicity, the sequestrum lying bare in the wound perhaps for years without being separated, owing to the slight degree of vascularity and the extreme condensation of the surrounding parts. It is quite unusual at the present day to see cases of this nature. In the *shafts of long bones*, where the compact tissue is thick and resistant, there may be extensive periosteal disease, with but little affection of the underlying parts; but if this compact layer is thin, and especially when the cancellous ends are involved, a considerable amount of destruction from caries may result, though if pyococci are not admitted there will be an entire absence of necrosis.

The *sternum* is not uncommonly affected by syphilitic disease, which manifests itself as a gumma. which breaks down and sup

purates, but does not often cause much bone destruction. The *nasal bones* and *hard palate* are frequently the site of subperiosteal gummatous formation, resulting in suppuration and necrosis; a foul discharge from the nose results in the former case, which may be followed by destruction of the septum nasi and permanent deformity. The palatal trouble often results in perforation.

In the **Treatment** constitutional remedies must be employed, and will be valuable if suppuration and necrosis have not occurred. They may have but little effect, however, if pyogenic infection has supervened, apart from measures directed to providing effective drainage and removal of the dead bone. In the calvarium, however, no attempt should be made to take away the dead bone unless it is loose.

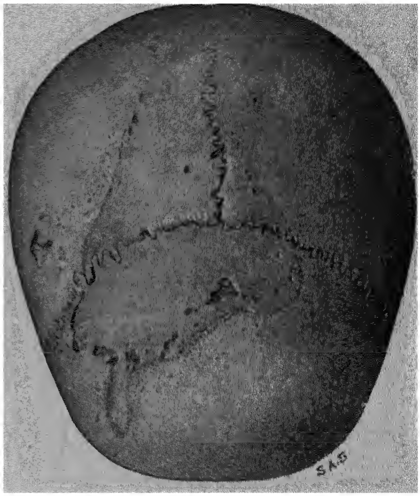


FIG. 280.—SYPHILITIC NECROSIS OF THE SKULL (KING'S COLLEGE HOSPITAL MUSEUM.)

The sequestrum is becoming separated, and a ring of caries is forming around it

(*c*) Occasionally a *gummatous osteomyelitis* is met with, in which a gumma forms in the interior of a bone. It results in the so-called expansion of bone and secondary thickening—*i.e.*, a chronic osteo-periostitis, limited usually to one end of the bone at first, but subsequently affecting the whole shaft. It has often been mistaken for malignant disease, and amputation considered or undertaken. The greater rapidity of growth in the syphilitic cases, and the evidences of tertiary lesions elsewhere, or of a syphilitic history, and the existence of a positive Wassermann reaction, will often guide the surgeon to a right conclusion, whilst radiography is also helpful; but if there is any doubt an exploratory incision and a microscopic examination of the diseased tissues should always be made before amputation is undertaken.

In **Inherited Syphilis** any of the above manifestations may be seen, but with more or less special features added, and, in addition to these, certain forms which do not occur in the acquired type of the disease have been described.

1. A new formation of bone beneath the periosteum is perhaps the most frequent result, and this occurs with but little pain. Perhaps the most common situation of this lesion in infants is the calvarium, where bony masses known as *Parrot's nodes* form around the anterior fontanelle, causing the top of the skull to resemble a 'hot-

cross bun ' in shape. In the early stages the bone is soft and spongy, and on post-mortem examination is dark red or maroon in colour. If the process is not checked by suitable antisyphilitic treatment, the newly-formed osseous tissue becomes dense and sclerosed, and the deformity may then persist through life (Fig. 38, p. 184). Any part of the calvarium may, however, be affected, and the change is not necessarily limited to the first years of life.

2. A somewhat similar condition is met with in the shafts of long bones, due to the deposition of alternating lamellæ of soft and hard bone outside the ordinary compact tissue and beneath the periosteum.

3. *Syphilitic epiphysitis* (or, as it is termed, syphilitic *osteochondritis*) is a lesion characterized by enlargement of the ends of the bones, as in rickets, but coming on within the first year after birth. The enlargement is mainly situated in the epiphysis, but also extends some way along the shaft, thus contrasting forcibly with rickets. Occasionally only one side of the epiphysis is affected. The change commences in the zone of calcified cartilage nearest the diaphysis, which becomes friable, opaque, and irregular, and as the condition progresses it may be transformed into granulation tissue, so that separation of the epiphysis follows. Pyogenic infection may follow, resulting in suppuration and necrosis of the epiphysis or acute arthritis, or the limb hangs powerless in a condition known as *syphilitic pseudo-paralysis*. The disease is usually symmetrical, and often multiple, and situated in much the same positions as rachitic affections, the knees, elbows, and wrists being perhaps most often affected. It may terminate in the early stages, and be followed by organization of the granulation tissue, the ultimate result being cessation of growth in the bone.

4. A symmetrical overgrowth of the tibia, perhaps combined with an anterior curvature, also occurs in syphilitic children, resulting in permanent elongation of the legs (p. 504).

5. *Craniotabes* consists of a localized absorption of the osseous tissue of the cranium, leaving small areas where the bone is thinned or absent, so that on pressure a sensation of crackling, like that of parchment, is imparted to the finger. It occurs most frequently in the parietal bone, and in the majority of cases within the first six months of life, a fact that throws considerable doubt on the idea that it is due to rickets.

The **Treatment** of syphilitic lesions in children must be carried out in accordance with general principles, and mainly by the administration of suitable drugs.

Rickets.

Rickets is a disease occurring in children and manifesting itself mainly in lesions connected with the bones. It usually commences within the first three years of life, but sometimes appears later.

Causes.*—Much work has been undertaken during recent years to solve the ætiological problem of rickets, and it now seems certain that at least three elements combine in order to bring about the disease: (1) Deficiency of the *antirachitic vitamin D* in the diet; it is present in good milk, eggs, and butter, but apparently the amount in milk varies with the diet and management of the cow, being more abundant when the animal receives fresh green food and lives in the sunshine. Cod-liver oil contains the largest amount of antirachitic vitamin of any known substance. (2) *Sunlight*, and especially the ultra-violet rays in the spectrum, are essential if healthy bone formation is to occur. The abundance of sunshine of the tropics explains the rarity of rickets in these regions, and the nature of the food available in the Arctic circle, largely blubber, provides the antirachitic factor which balances the lack of sunshine there experienced. (3) A sufficiency of both *calcium and phosphorus* must be present in the food if healthy bone is to be formed. Good milk contains an abundance of these in a suitable form, but cannot prevent rickets apart from other factors. When the diet consists largely of cereals or carbohydrates, defective intake of Ca and P may have a distinct causative influence.

Rickets is therefore a deficiency disease, induced chiefly by improper or insufficient food, especially by the too early administration of starchy materials and the want of suitable fats, whilst uncleanliness and the absence of sunlight and fresh air predispose to it. The crowded streets and houses of the poorer sections of our great cities are obviously magnificent factories of this disease. Syphilis has no direct causative connection with rickets.

The **Symptoms** may be divided into the early or general, and the later or osseous. The *general* symptoms commence with the child becoming feeble and fretful, losing its power of walking if this has been attained, and its muscles generally are hypotonic. The child may be fat and flabby, or thin and emaciated; the mucous membranes are pale, and vomiting and diarrhœa are constantly present, the motions being often green, slimy, and very offensive. The spleen is enlarged, the abdomen tumid, and profuse sweating of the head is very characteristic.

The commencement of the *osseous changes* is usually indicated by increasing irritability and restlessness, the child tossing off his bedclothes at night, and crying out when handled or touched. The articular ends of the long bones become enlarged, as also the junction of the costal cartilages with the ribs. Sooner or later the shafts of the long bones soften, and may bend in various directions, and thus many *deformities* may be produced.

The *head* usually becomes flattened antero-posteriorly, so that the forehead appears square in shape and enlarged, whilst frontal bosses may develop on either side, due to new formation of bone

* Report on the Present State of Knowledge concerning Accessory Food Factors (Vitamins). Second edition, 1924. H M. Stationery Office.

under the periosteum; it is a question, however, whether these are not syphilitic rather than rachitic in orgin. The fontanelles remain open much longer than usual, and craniotabes is said to occur. The teeth do not erupt till late, and are stunted, defective in enamel, and easily eroded, so that the ends of the incisors are often concave; they must not be mistaken for syphilitic teeth, since the concavity is a small arc of a large circle, while the typical notch of syphilis is a large segment of a small circle.

The *spine* may be affected by kyphosis (p. 486), or less frequently by scoliosis (p. 481); the kyphotic curve results when the patient is allowed to lie too much in bed with the head on a high pillow, or if the child is carried about with a curved back; scoliosis more often occurs when the patient is able to walk. Occasionally a kypho-scoliosis is produced as a result of the child being carried about sitting on a nurse's arm with the pelvis tilted.

Changes in the *thorax* are produced by enlargement of the costo-chondral junctions (*beaded ribs*), which, when present on either side of the sternum, produce what is known as the *rickety rosary*. The swelling is more marked on the pleural aspect than on the outer side of the bone. If there is any obstruction to the entrance of air into the lungs, as from tracheitis or bronchitis, the atmospheric pressure may cause the softened bone and cartilage to sink inwards, and as a result of this the sternum may be pushed forwards (*pigeon breast*), whilst the curvature of the ribs at the angle is increased. A very characteristic feature of the rickety change consists in the lateral groove thus produced on each side of the sternum, which may meet with a transverse depression below, caused by the projection of the lower floating ribs by the tumid abdomen.

The *pelvis* is flattened antero-posteriorly, or more rarely is tri-radiate, the former condition being produced when the patient lies habitually on his back, the latter only occurring when walking is permitted, the acetabula being then pressed inwards and backwards by the heads of the femora.

The deformity of the *long bones* (Fig. 281 and R.S., Fig. 29) usually consists in an increase of their natural curves, especially at points where powerful muscles are attached. The femora are curved forwards and outwards, and the tibiæ in a similar direction (Fig. 175), although not uncommonly the lower end of the tibia is bent inwards. Genu valgum or varum may also result from these changes (pp. 500 and 503).

When the acute stage of rickets has passed away, any deformities present become fixed by the complete ossification of the softened bony tissues. As a rule the density of such deformed bones is increased, whilst their natural shape is altered by deposits of new subperiosteal bone or struts in the concavities, so that on section they are usually more or less flattened from side to side, and the medullary canal appears to be displaced towards the convexity. Growth is often checked by this disease, and thus the individual becomes stunted and dwarf-like.

Pathologically the chief changes in rickets are found in the neighbourhood of the epiphyses. Ordinarily, the epiphyseal cartilage is a lamella about a line in thickness, bounded on either side by a zone of calcified tissue, containing regular alveolar spaces filled with vascular medulla, and lined by osteoblasts, passing gradually into normal cancellous bone In rickets the epiphyseal

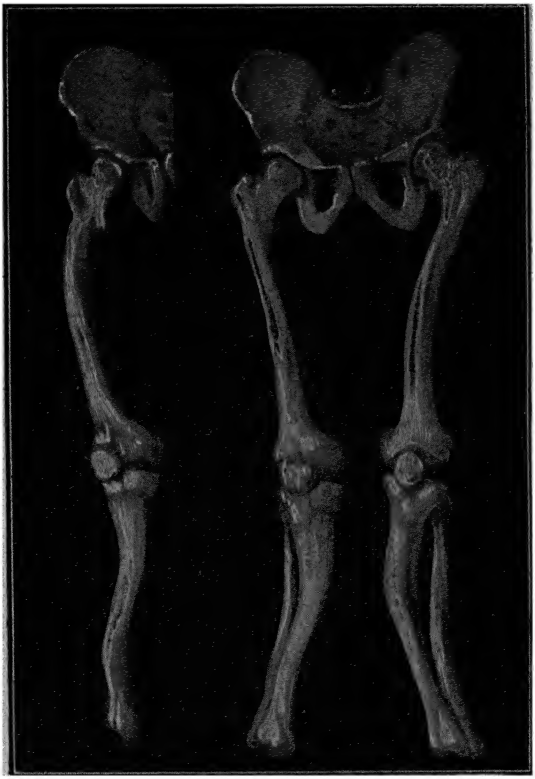


FIG. 281.—PELVIS AND LEG-BONES IN RICKETS (FROM COLLEGE OF SURGEONS' MUSEUM.)

The photograph of the left is taken from the side, in order to show the extent of the antero-posterior curvature of the bones.

cartilage is not only circumferentially enlarged, but also thickened and irregular (Fig. 282), outgrowths of cartilage projecting on either side into the calcified tissue, which is more abundant and more open in texture than usual, whilst it passes irregularly into the cancellous bone. Thus, there is an increased preparation for the formation of bone, but the ossifying process is inefficiently carried out. In addition to this, the Haversian canal systems and the

medullary spaces in the diaphyses are enlarged, so that the bones become weaker and less rigid from the insufficient amount of lime salts present, and thus readily bend under the weight of the body or from muscular action. Less frequently the subperiosteal compact bone becomes similarly rarefied. When the disease comes to an end, the deformities may persist, but the bone, now effectively ossified, becomes harder and stronger than usual.

In the **Treatment** of rickets the most essential feature in the early stages is the correction of all errors in the personal hygiene. The diet should consist of good cow's milk, diluted if need be, and with lime-water added; whilst the juice expressed from raw beef, or one of the many meat juices now sold, may also be administered. The condition of the bowels must be attended to, and the child placed in as good surroundings as possible. Cod-liver oil is the all-essential medicine, containing an abundance of the necessary antirachitic vitamin; it may be administered in combination with Parrish's food (syr. ferri phos. co.). Exposure to sunshine is perhaps best delayed until the general symptoms of the acute stage have passed; if it be not obtainable, the ultra-violet rays of the arc lamp should be substituted. Deformities should be prevented by keeping the child in the recumbent posture, and not allowing it to crawl or run about. The early stages of deformity can often be corrected by daily manipulation of the affected bones; for the legs, it may suffice to keep the child off its feet, as by a splint which extends from the thighs 6 inches below the soles; a certain amount of pressure can also be exercised by this appliance. Osteotomy, or even resection of portions of bone, is required in the severer cases where the deformity persists, and the bony changes have become consolidated (see p. 504).

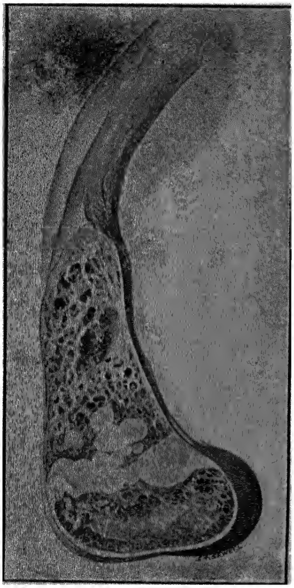


FIG. 282.—SECTION THROUGH LOWER END OF RICKETY FEMUR, SHOWING EXAGGERATED DEPTH AND IRREGULAR BORDERS OF THE PROLIFERATING EPIPHYSEAL CARTILAGE (COLLEGE OF SURGEONS' MUSEUM.)

Adolescent Rickets comes on about puberty, and is usually independent of an early rachitic history, although in a few cases it may be looked on as a recrudescence of the infantile ailment. Imperfect nutrition is probably a less important ætiological factor than in infancy; but strain, mental or physical, combined with defective hygiene, has been present in most instances. The chief changes are to be found in the shafts of the long bones of the legs, which

become bent from the superjacent weight of the body. Deformities in the upper extremities are less frequent. Enlargement of the epiphyses is also observed. There is usually no sweating of the head, but the patient is pale, and complains of fatigue and languor, but not of pain. The softened bones bend, and no buttresses or struts are formed in the concavities; hence the deformities produced are often serious, and the course of the case is slow. (See Fig. 174, which was taken from a girl of thirteen years, the subject of this affection) *Treatment* is undertaken along the same lines as for the infantile variety, cod-liver oil and sunshine being the two essentials; undue mechanical strain must be avoided, and, if need be, the patient is kept at rest. Deformities are dealt with by the use of orthopædic appliances or by osteotomy.

Infantile Scurvy (*syn.*: **Barlow's Disease, Scurvy Rickets, Hæmorrhagic Rickets**).—This condition, first accurately described by Sir Thomas Barlow, presents the symptoms of scurvy in a rachitic child, and in its manifestations either one or the other set of phenomena may predominate. It is usually seen in the children of well-to-do people from four to eighteen months old, and apparently arises from defective nutrition, especially from the prolonged administration of peptonized or prepared foods, or even possibly of sterilized milk. In the slighter cases there may be but little evidence of the scorbutic condition, beyond the fact that in a rickety child there is some tendency for the gums to bleed, or a little hæmaturia; but in those that are more marked the rickety signs are of little importance compared with those due to hæmorrhagic extravasations. The disease often comes on suddenly with some amount of pyrexia, rarely exceeding 102° F., but the child is evidently ill, and perhaps complains of tenderness of the limbs, which may be kept so quiet as to suggest that they are paralyzed. This is followed by the appearance of swellings of some size, due to sub-periosteal extravasations, the skin over the affected parts being at first shiny and œdematous, but subsequently becoming stained by the blood-pigment. The femur and tibia are most often affected in this way, and the epiphyses occasionally become detached, or even spontaneous fractures may occur. Bleeding may also take place beneath the conjunctiva or in the orbit, leading to protrusion of the eyeball, whilst there may be blood-stained diarrhœa, hæmaturia, or epistaxis.

The disease, when recognized, is readily amenable to *treatment*, but should its nature be overlooked, the child is likely to become emaciated and die. Attention to the diet is the main point to be attended to, for when fresh milk, lime-juice, or vegetables are given, the symptoms soon disappear. The affected limbs must be kept at rest, and cooling lotions applied, whilst splints are required when epiphyses are separated or fractures have occurred

Achondroplasia (Chondrodystrophia fœtalis) is a curious congenital condition, somewhat resembling rickets, in which the growth of osseous tissue on the shaft side of the epiphyses of the long bones of both arms and legs is defective, so that the limbs are short and stunted, and the stature correspondingly diminished, although the epiphyses are normal. The bones generally are not bent or curved abnormally, though there is probably some change of the neck or shaft of the femur, resulting in lordosis, which is very marked when the patient stands. The fingers taper to their tips, and are separated one from another in 'spoke-like' fashion. The bones at the base of the skull, being of cartilaginous origin, undergo premature synostosis, whilst the upper half of the skull, being derived from membrane and therefore developing naturally, looks unusually large; the face is small, and the bridge of the nose depressed as in congenital syphilis. The children, if they live, are usually efficient in their mental development, and the thyroid body normal. No known treatment is of any value.

Renal Dwarfism was first described by Barber in 1913, and is of interest to the surgeon owing to the fact that in about 70 per cent. of cases there are bony deformities. The disease is characterized by severe chronic interstitial

nephritis associated with deformities of the limb bones, which make their appearance from the eleventh to the fourteenth years. The changes in the bones resemble those of rickets, but the X-ray appearances are distinctive and characteristic. Skiagrams show a much greater regularity of the epiphyseal line as compared with rickets, although the detail is frequently blurred owing to osteoporosis. The deformity is not due to bending the shaft of the bone, but to displacement at the epiphyseal line.

Osteogensis imperfecta (or **idiopathic psathyrosis**) is a rare *congenital* condition, characterized by a defective development of osseous tissue from cartilage, so that the bones are brittle or soft, and thus are easily bent or broken, constituting a condition of *fragilitas ossium*. Nothing is known as to ætiology, except that there is a strong hereditary tendency. It is possibly due to some change in the parathyroid glands, which apparently control the calcium metabolism Not a few of the subjects are stillborn, with broken or deformed limbs, whilst many die within the first year of life. Cases in which fractures occur more or less spontaneously and frequently in older life are probably due to some other condition, such as osteomalacia. If the child lives, one fracture occurs after another, and the limbs may become terribly deformed, although with care they usually unite well. In addition to the deformities due to the malunion of fractures, the bones are usually bent and distorted, and thus the case may be confused with rickets or osteomalacia. The cranial bones sometimes participate in the process, and are deformed; the sclerotics are of a bright blue colour. The actual anatomical changes in the bones consist in the persistence of cartilage cells in their capsules and calcification of the trabeculæ between, very little bone being formed, and that of a defective type The administration of parathyroid extract is justifiable, and calcium salts may be useful; otherwise all that can be done is to protect the patient from mechanical injuries and treat the fractures as they occur.

Mollities Ossium (*syn.:* **Osteomalacia**) is an *acquired* disease of somewhat unusual occurrence, characterized by the absorption of the osseous substance of the bones, as a result of which softening and rarefaction are produced, followed by bending or spontaneous fracture.

The complaint is almost limited to the female sex (only 8 per cent. of the cases reported are in males), and often commences during pregnancy; it is said to be sometimes connected with a rheumatic tendency. Any part of the skeleton may be affected; in females the change usually attacks the pelvis, spinal column and ribs first, and the limbs later; in men the process starts in the long bones.

Pathologically, the change consists in a replacement of the medullary substance by a soft fibro-cellular tissue, which is exceedingly vascular, and into which hæmorrhage often occurs; the resulting material looks in the fresh state somewhat like splenic pulp. The bony cancelli are absorbed, as also the greater part of the compact tissue, with the exception of a thin layer situated beneath the periosteum; in a well-marked case the mineral salts may be diminished to about one-sixth of their normal amount, but the relative proportion of phosphate of lime to the carbonate is not changed. Part of the bone substance remains for a time in a decalcified state, with the corpuscles evident, but in a condition of fatty degeneration. Possibly some acid—*e.g.*, lactic acid—is the active agent in dissolving the earthy salts, which escape partly in the urine, partly in the fæces. The process is probably connected with the absorption of some internal secretion, normal or vitiated, particularly that from the ovary, since the removal of the uterine appendages has in a few cases stayed the disease.

Clinically, the onset is somewhat indefinite, the only complaint being of pain in various parts of the body, whilst the patient becomes emaciated and exhausted. Sooner or later skeletal changes ensue and demonstrate the character of the disease. In women the mischief usually commences in the pelvis, which becomes flattened at first, and subsequently triradiate, owing to the acetabula being pressed inwards and backwards by the weight of the body, and in pregnant women this may cause so much deformity as to necessi-

tate Cæsarean section. The spine becomes curved, whilst the limbs bend and break, in the latter case sometimes no attempt at repair is made, or healing may occur with deformity. Death may result from exhaustion, or from obstruction to parturition, or the patient may live more or less bedridden for years, the limbs becoming useless, shortened, and perhaps contorted in a strange and abnormal fashion. In women the disease may cease to progress, or even recovery may occur at the menopause.

Treatment is unsatisfactory. Opiates may be administered to relieve pain, which is often very severe, and various drugs, such as alum, and phosphate or hypophosphite of lime, have been recommended In cases not associated with parturition or pregnancy, oöphorectomy is said to have been employed with benefit. The induction of premature labour is considered by some to

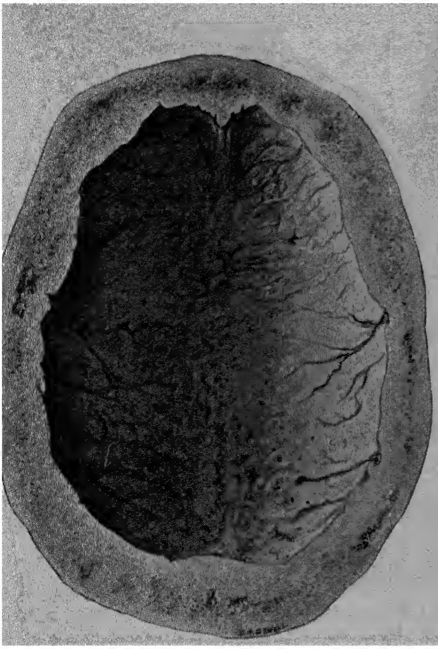


FIG. 283.—CALVARIUM IN OSTEITIS DEFORMANS (ROYAL COLLEGE OF SURGEONS' MUSEUM.)

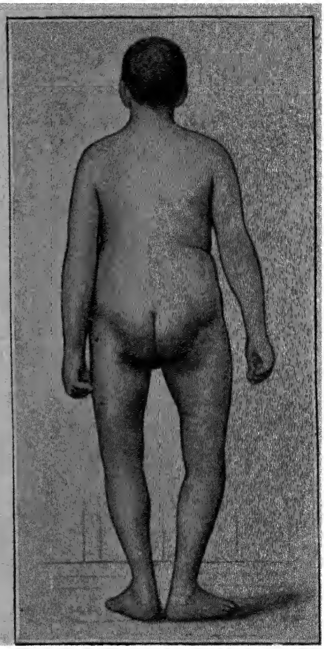


FIG. 284.—EARLY STAGE OF OSTEITIS DEFORMANS.

be beneficial, not only for the sake of obviating the necessity for such operations as Cæsarean section, but also on the chance of checking the disease.

Osteitis deformans is an inflammatory disease of the osseous skeleton, first described by Sir James Paget in 1876. The onset is insidious, and the progress very slow. It is characterized by a painful overgrowth of the long bones, spine, cranium, and pelvis, which are also softened, so that those which bear the weight of the body become curved. It may commence in one bone alone, and then usually the tibia or femur, but more often many bones are affected at the same time (R.S., Fig. 27). Attention may be drawn to the condition, either by the pain, which the patient at first considers to be rheumatic, or by the general enlargement and bending of the bones, or by the increased size of the head, necessitating the use of larger hats. The cranial overgrowth is eccentric

in character, and the calvarium may become very thick (Fig. 283); the facial skeleton, however, is not much affected (Fig. 285). The spine becomes markedly kyphotic (Fig 284), the dorsal curve being increased, and the lumbar concavity obliterated, it is nearly rigid from ankylosis of the vertebræ, and may be very painful. In the later stages the head is carried forwards by the bent spine, the height is diminished, the shoulders are round, and the chest sunken towards the pelvis, the gait is slow and awkward The disease usually attacks middle-aged men; its progress is exceedingly slow, the patient often living to an advanced age, or dying from some intercurrent malady Some cases have terminated in sarcoma or endothelioma of the bones The structure of the osseous tissue is suggestive of inflammatory rather than degenerative changes. It is softer and more uniform in structure than usual, the difference

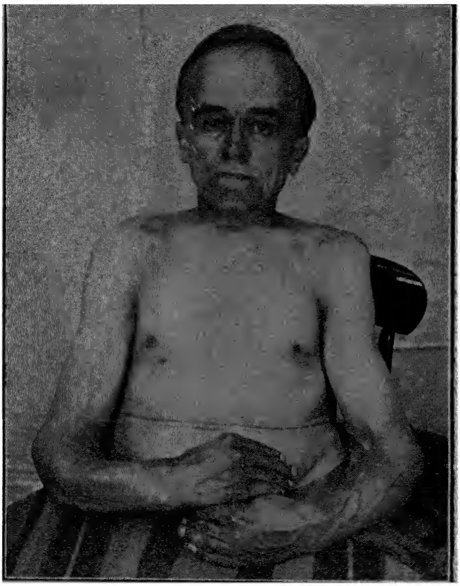


FIG. 285.—OSTEITIS DEFORMANS IN LATE STAGE.

Note size of the skull and curvature of humerus and of bones of forearms.

between the cancellous and compact tissue being less defined; the Haversian canals are large, and arranged irregularly, whilst the bony substance looks chalky, and the calcium content is subnormal.

Differential Diagnosis.—From *arthritis deformans*, which it resembles by the attitude and gait of the patient, it is known by the absence of articular lesions, especially in the fingers, and the enlargement of the bones, notably of the cranium. From *acromegaly* it is distinguished by the absence of enlargement of the hands, feet, and lower jaw.

Treatment is purely symptomatic, no remedy at present known having any control over the disease.

Acromegaly is a rare condition, the characteristics of which were first described by Dr. Pierre Marie in 1885. It is a general affection involving mainly the osseous system, commencing usually in young adults, and, after lasting

for a long time, killing the patient by syncope or cerebral compression, if some intercurrent malady does not destroy him.

It is characterized by a very definite enlargement of the hands and feet, which are, however, not lengthened, so that the hands have been compared to battledores, and the fingers to sausages. The bones themselves are enlarged; and the soft structures on the palmar aspects project as pads. The nails and skin are unchanged, whilst the other segments, both of the upper and lower limbs, are usually unaffected, though sometimes considerable overgrowth in length occurs; in fact, many of the so-called giants who have been exhibited are typical illustrations of acromegaly. Both the upper and lower jaws are thickened and prominent (Fig. 286), whilst the lower lip is enlarged and overhanging The orbital ridges project, and the forehead is usually low; the nose and tip of the tongue are also more or less enlarged. The spine is kyphotic in the dorsal region, with a slight lumbar lordosis. The ribs and sternum project anteriorly.

The patient usually suffers from headache, lassitude, and great fatigue wandering pains about the body, and excessive appetite and thirst; amenor

Fig. 286.—Head of Woman with Acromegaly. Seen from the Front and from the Side *

rhœa is a marked symptom in women, whilst men suffer from a loss of virile power. The urine is abundant, but of a low specific gravity. Vision is usually diminished, and optic neuritis has been observed in some cases.

Morbid Anatomy.—The cause of acromegaly appears to be overgrowth of the anterior half of the pituitary body (p 879), and excessive absorption of its secretion (hyperpituitarism). The sella turcica is expanded, and this can be recognized by X rays. The changes in the bones are merely those of overgrowth.

Diagnosis.—The disease has been mistaken for *myxœdema*, but there is not much difficulty in distinguishing the two if it be remembered that, in the latter condition, the skin is not mobile over the thickened subcutaneous tissue; that the face is broad, pasty, and puffy; and that masses of gelatinous tissue are found above the clavicle; whilst in acromegaly the face is elongated and the skin and subcutaneous tissues normal. The mental condition and speech of a patient suffering from myxœdema are widely different from those in acromegaly; whilst in the former the thyroid body is either absent or diseased,

* Reproduced from the *Edinburgh Medical Journal*, by kind permission of the late Dr. G. A. Gibson.

and in the latter skeletal changes are present. From *chronic osteo-arthritis* affecting the hands the diagnosis is easy, in that there are usually no signs of articular disease, and much less pain From *osteitis deformans* the distinguishing features have already been indicated.

Treatment is merely symptomatic, antipyrine being useful in relieving the headache, as also valerianate of caffeine Possibly thyroid extract may be of some use in combating the functional phenomena, though it will not influence the skeletal changes. Attempts have been made to remove the growth by operation with some degree of success, though naturally the mortality is high (p. 879).

Hypertrophic Osteo-Arthropathy—It has long been known that clubbing of the terminal phalanges is associated with chronic pulmonary and cardiac disease (Fig 287); and it is probable that such is the earliest stage of this more generalized affection, first described by Pierre Marie. In it the ends of the fingers and toes are enlarged and bulbous, with the nails curved over towards the palm or sole; in the early stages the change may be limited to the soft tissues, but radiography has demonstrated that in the later there is a well marked new formation of bone along the shafts of the phalanges, and also of

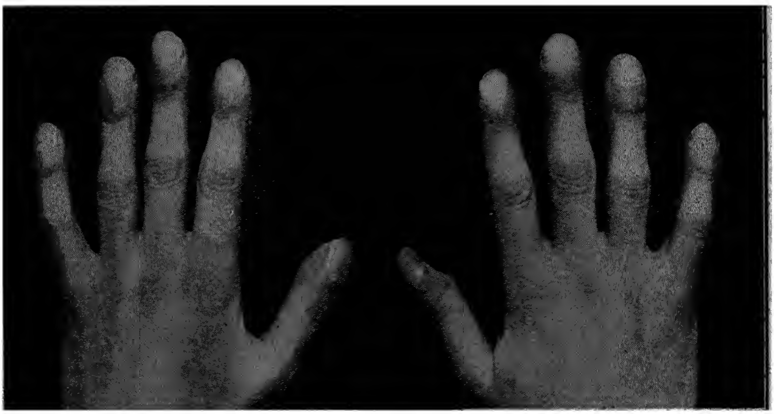


FIG. 287—CLUBBED FINGERS DUE TO CHRONIC EMPYEMA

the metatarsal and metacarpal bones. There is a considerable swelling of the bones just above the wrists and ankles, extending some way along the shafts, and similar bony enlargements sometimes occur elsewhere, they are due to a diffuse osteo-periostitis. The spine is kyphotic in the upper dorsal region, but with well-marked lordosis below. It is thus seen that the changes are somewhat like those of acromegaly, from which they are distinguished by (*a*) the implication chiefly of the fingers and toes, and particularly of the terminal phalanges, whilst in acromegaly the enlargement of the different portions of the hands and feet is general; (*b*) the nails are not affected in acromegaly; (*c*) the joints are but little involved in acromegaly; and (*d*) the enlargements of face, tongue, jaw, etc , so marked in acromegaly, are absent in osteo-arthropathy. These phenomena probably result from chronic toxic absorption, since the condition arises in such diseases as chronic bronchitis, bronchiectasis, and chronic empyema, where suppuration has existed for some time. It is, however, sometimes associated with lesions other than pulmonary—*e.g.*, chronic jaundice, syphilis, and influenza—and has even been found in otherwise apparently healthy individuals Little can be done in the way of treatment, except to deal with the cause, if obvious.

Tumours of Bone.

The characters of the osteomata, chondromata, and fibromata of bone have been described in Chapter VIII., and various solid and cystic tumours connected with the teeth are dealt with elsewhere.

Myeloma (Fig. 288) is practically a benign tumour, rarely giving rise to secondary deposits either in lymphatic glands or viscera, and its growth within the bone is strictly limited, with no tendency to diffusion along the medulla; occasionally a layer of condensed bone demonstrable by radiography forms an effective barrier in this direction. For its pathological features, see p. 217. The sites of

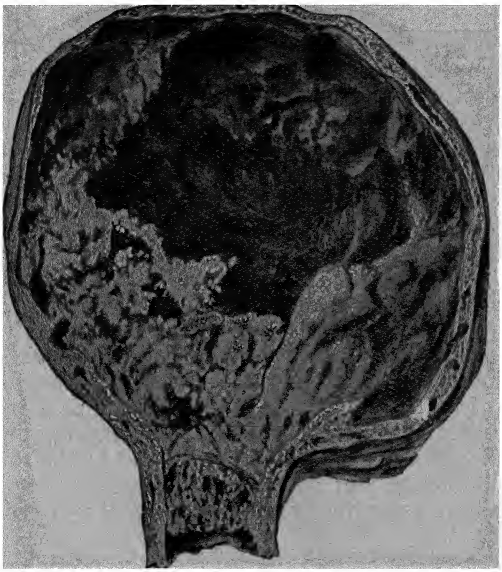


FIG. 288.—MYELOMA OF HEAD OF TIBIA. (KING'S COLLEGE HOSPITAL MUSEUM.)

election for myeloid tumours are the growing ends of the long bones, especially the lower ends of the femur and radius, and the upper ends of the humerus, tibia and fibula, whilst they also occur in the diploë and lower jaw, and constitute one form of epulis. The development of the tumour leads to the so-called *expansion* of the bone, in which the osseous tissue is absorbed from the inner aspect, and new bone is laid down externally; the outer layers, however, gradually become thinned, so that after a time the osseous lamina can be pressed inwards, giving rise to a feeling known as 'egg-shell crackling'; and finally the tumour projects through the bony wall. This expansion may be central, and the bone end thus becomes more or less globular, or it may be eccentric, and then the growth

projects merely on one side. Sooner or later spontaneous fracture is likely to occur. Neighbouring joints usually escape, but in old-standing cases the growth may project around the articular cartilage and somewhat impair the movements; there may, however, be some serous effusion in the cavity. The **Symptoms** may be so slight at the commencement that nothing is noted until fracture has taken place; but sometimes pain similar to that of a chronic osteo-periostitis draws attention to the enlargement of the bone. Radiographic examination reveals a well-defined area of bone, which is unduly translucent, but with a characteristic 'stippling,' due to the presence of calcareous foci scattered through the growth. The accurate limitation of the growth, and its demarcation from the medullary cavity, are important diagnostic signs.

Treatment is governed by the assurance that a myeloma is non-malignant, and hence may be dealt with in a conservative manner by a localized removal of the growth, amputation being reserved for the more advanced cases and for those where a local removal would leave a more or less useless limb. In quite the early stages it suffices cleanly to excise the growth, or if that is impracticable, to incise and scrape it away with a sharp spoon, closing the wound without drainage, possibly after filling it with fat or muscle grafts. Subsequent exposure of the part to radium or X rays is desirable in order to complete the destruction of the growth. In a later stage the affected portion of the bone may be completely removed, and if necessary the gap bridged by bone-grafting. Thus a myeloid tumour of the upper end of the fibula can be excised, care being taken of the external popliteal nerve and its branches; but if the upper end of the tibia or lower end of the femur is involved to the extent of destroying most of the bony substance, amputation may be required. When affecting the lower end of the radius or upper end of the humerus, and not in too advanced a stage, an attempt may be made to save the limb by excising the diseased portion of bone. In the wrist the lower part of the ulna is taken away, as well as the growth in the radius; by this plan there is less chance of the hand being drawn up and abducted, and hence it is more likely to be of use subsequently.

Sarcoma is the most important primary tumour of bones, and almost any variety may occur. The microscopical characters have been detailed in the chapter on tumours, and we shall here chiefly refer to their *clinical characteristics*. They may be divided into two main groups—the endosteal or central, and the periosteal.

Central Round- or Spindle-celled Sarcoma is of an extremely malignant nature. There is usually more pain than with a myeloid growth, since its development is much more rapid, but the bone may be but little expanded (Fig. 289), since the growth diffuses itself along the medullary cavity and encroaches more closely upon the neighbouring joint. The outer wall is likely to be absorbed earlier than in a myeloma, and invasion of the surrounding tissues or spontaneous fracture results. Lymphatic glands and viscera

are soon involved by dissemination of the disease. The tumour substance itself is usually of a soft nature, not containing much newly-formed bone; cartilaginous and myxomatous foci are often associated with it. The growth is highly vascular, and cysts may form therein, but not so frequently as in the myeloid tumours. Radiography shows an irregular removal of bony tissue, and there is no defined limiting zone of thickened bone around the growth. The rapidity of growth and the radiographic characters are the features on which a diagnosis of a malignant endosteal sarcoma must be based (R.S., Fig. 24).

FIG. 289.—ROUND-CELLED ENDOSTEAL SARCOMA DISSEMINATING ITSELF IN THE MEDULLARY CAVITY. (KING'S COLLEGE HOSPITAL MUSEUM.)

Periosteal Sarcomata are round- or spindle-celled in nature, and occur less frequently than the endosteal variety. They often develop rapidly without giving rise to much pain, unless causing erosion of the bone. They usually start on one side, but may surround the whole circumference later on, and spread for some distance along the shaft. A high degree of malignancy is attained by them, secondary growths forming in lymphatic glands or the viscera. Ossification often occurs in their substance with or without the previous development of cartilage, and in such cases the subjacent bone may become sclerosed and thickened, so that spontaneous fracture is not common in this variety. The bony skeleton

of such a growth is very characteristic, consisting of fine spiculated trabeculæ, radiating more or less regularly from the surface, and looking in the dried state somewhat like asbestos (Fig. 290). These ossifying sarcomata have a very characteristic appearance on radiography. When a periosteal sarcoma does not become ossified, the growth often erodes the underlying bone (Fig. 291), and may lead to spontaneous fracture; the tumour in such cases is softer and more elastic than in the former variety, and usually attacks the bone from one side and not equally all round (R.S., Fig. 25). Osseous

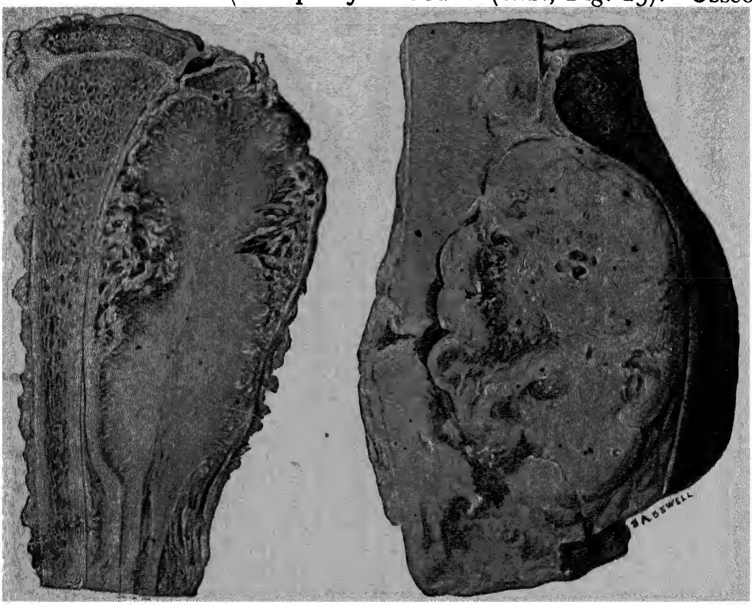


FIG. 290 —OSSIFYING PERIOSTEAL SARCOMA OF FIBULA. (KING'S COLLEGE HOSPITAL MUSEUM.)

FIG. 291.—SOFT PERIOSTEAL SARCOMA OF LOWER END OF FEMUR, ERODING BONE AND LEADING TO SPONTANEOUS FRACTURE. (KING'S COLLEGE HOSPITAL MUSEUM.)

sarcomata are always exceedingly vascular, and may even pulsate, whilst the superficial veins are obviously dilated beneath the stretched integument, giving rise to a blue network.

The **Diagnosis** of osteo-sarcoma in the early stages is unfortunately often a matter of the greatest difficulty. The *endosteal* form may easily be mistaken for chronic osteo-periostitis, medullary gumma, or a deep abscess of the bone, and can sometimes only be distinguished from them by an exploratory incision and microscopic examination of a portion of the growth; this should always be undertaken in doubtful cases prior to radical operations, such as amputation. In the later stages, the presence of ' egg-shell crackling ' or

cystic changes will help to make evident the nature of the disease. The *periosteal* form may at first be looked upon as a periosteal node, or a deeply-placed abscess. The rounded and definite edge of the growth, its irregular consistency, and the history of the case, will assist in the determination of its nature; but in the early stages an exploratory operation is not unfrequently necessary. For the diagnosis of a pulsating sarcoma from an aneurism, see p. 354. When either form involves the articular end of a bone, especially the lower end of the femur, it may simulate tuberculous disease of the adjacent bone. It will, however, be noted that the centre of the swelling corresponds to a point well above or below the joint, that a certain amount of movement is possible and even painless, whilst the starting pains at night characteristic of joint mischief are absent. The age of the patient, and the presence or not of cachexia, are also important features which have to be taken into consideration. Radiographic examination serves in most cases as an important diagnostic adjuvant.

It is of the greatest importance that a clear opinion as to the diagnosis be made at the earliest possible moment, as thereby both prognosis and treatment are immensely influenced. Periosteal sarcomata have a bad **prognosis,** as general dissemination occurs early; the small spindle-celled are the worst. Secondary deposits often contain ossific material, *e.g.* in the lungs. Central sarcomata are not quite so malignant, although the round-celled variety is decidedly unfavourable.

The **Treatment** of osteo-sarcoma is eminently unsatisfactory, as, even though the most radical measures are taken, recurrence is only too frequently observed, or death from secondary deposits occurs in spite of a successful issue locally; hence the importance of a thorough investigation, and, if need be, of an early exploratory incision in doubtful cases, cannot be over-estimated. Formerly, the rule that governed surgical practice was to amputate the limb well above the growth in all cases, and to ascertain by microscopic examination of the medulla at the time that it was free from disease. Thus, for a tumour of the lower end of the tibia, amputation through the knee would be practised; if the upper end of the tibia is involved, amputation through the middle of the thigh; and for a growth of the lower end of the femur, disarticulation at the hip-joint would be required for a periosteal growth, though for an endosteal one just below the trochanters might suffice. For a sarcoma of the upper end of the humerus, disarticulation of the shoulder was thought to be scarcely sufficient; it was usually considered wiser to remove the scapula in addition (interscapulo-thoracic amputation).

The results of such treatment have been so bad, and dissemination of the growth to the lungs so constant, that surgeons have almost completely laid aside such mutilating procedures, and trust rather to treatment with radium and X rays, combined with local excision where practicable. In some cases disappearance or diminution of the primary growth has been reported after burying radium in its substance for six or eight days, but, of course, this does not in

any way touch the question of secondary deposits. From an early diagnosis, and that alone, can any improvement be expected in the terrible statistics of the results of treatment of this dreadful disease (see p. 320).

Ewing's Sarcoma or Tumour is quite distinct from the rest of bone sarcomata, both clinically and histologically. The tumour is prone to occur in the skull bones and in the smaller bones of the extremities. It has a definite tendency to form metastases in bone; here again the skull is commonly affected. The X-ray picture is definite, the shaft of the bone being widened and having a striated appearance. Microscopically, the cells appear more embryonic in type than in those of periosteal sarcoma, and often show a perivascular arrangement with complete absence of intercellular substance. The prognosis is no better than in other cases of sarcoma of bone.

Secondary Sarcoma of bone is by no means uncommon. It is almost always endosteal in character, and, except in the most unusual circumstances, will not demand treatment, owing to the general infection of the system. Possibly where it has led to spontaneous fracture, and there is much pain owing to the difficulty of fixation, it would be justifiable to remove the limb.

Carcinoma of bone is always secondary in nature, although it may be involved by direct extension in a primary growth. Secondary growths are endosteal in character, and often extremely painful; they may occasionally lead to spontaneous fracture, but the bone may consolidate again satisfactorily. After scirrhus mammæ, the bones of the chest wall, the upper end of the femur and vertebræ are those most often affected.

Pulsating Tumours of Bone, or Osteo-Aneurism.—Apart from pulsating sarcoma, two other conditions are met with in which distinct pulsation is also noticeable. In the first of these the medullary cavity is occupied by a non-malignant vascular tissue, practically identical with what has been already described as an *aneurism by anastomosis* (p. 395). These tumours are situated most frequently in the cranial bones, and may be multiple, the medullary tissue being in consequence atrophied, and the compact tissue thinned, so that ' egg-shell crackling ' may be obtained. The second form is found most commonly in the upper end of the tibia, or some such cancellous mass. It consists of a hollow cavity filled with blood. Several distinct arterial twigs may open into it, and the overlying bone is thinned and absorbed. It is probable that the majority of such cases are in reality due to the breaking down of a sarcoma of extreme tenuity, or possibly of a myeloma. **Treatment.**—If it seems probable that the condition is not associated with malignant disease, the cavity should be incised, scraped, swabbed out with pure carbolic acid, and then packed with a muscle graft, or with gauze, so as to obtain healing by granulation. If the bleeding persists, amputation is the only treatment.

Hydatid Disease of Bone.—The cancellous tissue of bones occasionally becomes the site of hydatid development, any part either

of the medullary cavity or of the ends being involved. The bone becomes expanded, with all the symptoms of an endosteal growth. Considerable deformity may occur, and when the compact layer has been sufficiently absorbed, spontaneous fracture may follow. In this affection there is no limiting wall, the small daughter cysts being diffused through the affected area. Radiography and laboratory tests (p. 252) should suffice to ensure a diagnosis, but in countries where hydatid disease is rare, the condition is very liable not to be recognized until an exploratory incision has been made. **Treatment.**—If all the cysts can be removed without interfering with the integrity of the shaft, a recovery, with good subsequent utility of the limb, should follow. Where, however, the disease has encroached widely on the bony tissue, whether spontaneous fracture has occurred or not, amputation holds out the only prospect of cure, unless bone-grafting is feasible.

Simple Cysts of Bone are observed most frequently in the tibia or upper end of the humerus. The condition develops insidiously, probably without pain, and may be mistaken for a sarcoma, the true state of affairs not being recognized until after amputation of the limb; or attention may be drawn to the part by the occurrence of a spontaneous fracture. The cyst is found to be lined with a thin layer of fibrous tissue, with no endothelial covering. The actual pathology is not clear, but it is thought possible that it is akin to osteitis deformans or osteomalacia, since in all three conditions the true bony tissue disappears and the medullary tissue increases. In osteomalacia it remains fatty; in osteitis deformans new irregular bone is deposited in its place; and in this condition there is a new formation of fibrous tissue, which, however, subsequently becomes cystic. This *osteitis fibrosa*, as it has been termed, may be more or less generalized through a bone, or may be localized, and then a simple cyst may develop. The only available means of diagnosis, apart from incision, is radiography. The thinning of the bone is more regular than in any sarcomatous condition, and there is less mottling of detail such as is usually seen in cases of myeloid disease. **Treatment** consists in laying open the cavity, scraping it out, and packing, so as to determine healing by granulation; or by excising the affected portion of bone, and replacing it by a bone graft.

Affections of the Ribs and Sternum.

Osteomyelitis of the ribs is very unusual. Occasionally an acute pyococcal variety, running its usual course to necrosis, occurs in children; but the most common cause is typhoid fever (p. 648). The affection is then generally of a subacute type, and a more or less extensive cario-necrosis results. A special feature is the tendency of the bacilli to remain in a latent condition in the tissues, so that to ensure a perfect cure complete extirpation of the affected portion of bone is required.

Syphilitic Disease is more common in the sternum than in the ribs.

The upper part of the *sternum* is usually involved, and the affection is characterized by a formation of gummata in and upon the bone, which erode it, usually in a pitted fashion, and may cause necrosis. Treatment with iodide of potassium and mercury is required, and sequestra must be removed. In connection with the *ribs*, syphilis appears as a tertiary periostitis or perichondritis. A fusiform swelling develops with but little pain or tenderness; it may easily be mistaken for tuberculous disease or a new growth, but the history may help to a correct diagnosis, which can be confirmed by the Wassermann test.

Tuberculous Disease affects the ribs much more frequently than the sternum. In the *ribs*, it may arise primarily as an osteomyelitis implicating an extensive portion of the medulla; but it is not unfrequently secondary to tubercle of neighbouring parts, *e.g.* the spine or pleura, and then commences beneath the periosteum; several ribs may be involved at the same time. The disease is most commonly seen in young people, and affects either the middle of the rib or the costo-chondral junction. The usual manifestations of tubercle in bone are seen, giving rise to expansion of the bone, or to caries or necrosis, and suppuration is common. The abscess cavity may be mainly external to the ribs, but is not unfrequently hourglass-shaped, a narrow neck connecting the cavities which lie inside and outside the chest. *Treatment* in these cases may have to be of a radical type, including complete removal of an extensive portion of the rib and of the abscess cavity attached to it.

In the *sternum* tubercle runs its ordinary course, and may present an abscess which points either in front near the middle line, or may come forwards from behind through an intercostal space. Treatment is of the usual sanatorium type, but if an abscess needs to be opened, the opportunity should be taken of curetting the bone.

Tumours of the ribs and sternum are usually chondromata or chondro-sarcomata; perhaps the former are a little more common in the ribs, the latter in the sternum. The patient complains of but little pain, and therefore the cases are usually late in coming under observation. In time the growth becomes adherent to the pleura, and the lung itself may be invaded. In the early stages it is sometimes possible to remove them, although the lung is liable to collapse unless special precautions are taken.

Bone-grafting is an operation which has come much to the front of late, and is required for many ununited fractures, especially where there has been great loss of tissue, as also for reparative purposes where much bone has been removed with tumours or cysts, or for inflammatory conditions, as in tuberculous disease or infective osteomyelitis. It is also employed for purposes of fixation of joints or of the spine.

Formerly fragments of dead bone, or rods of ivory, were employed, but, of course, they are merely passive actors in the process of regeneration, being absorbed or replaced. Living bone, on the

contrary, is capable of retaining its vitality, and uniting with the surrounding parts, even if totally separated from its former osseous connections. The graft may be obtained from the patient himself (*autogenous*), or from another patient (*homogenous*), or from a freshly killed animal (*heterogenous*); but autogenous grafts are the only ones that can be relied on with any certainty, and even these require the most delicate handling if they are to survive and become effective.

The persisting capacity of bone cells to reproduce osseous tissue away from their old surroundings is the basis on which the success of bone-grafting depends. Unfortunately, this capacity is not always exercised in the direction the surgeon desires; thus new bone may form where it is not wanted, *e.g.* in cases of traumatic myositis ossificans; and it may fail to develop where most needed, as after fractures or bone-grafting. Sometimes a graft is absorbed completely after an apparently successful operation, and non-union follows. It is clear, therefore, that there are still some points in this procedure which are not fully understood.

Many methods of grafting have been employed from time to time, varying with the different ideas as to the destiny and usefulness of grafts, and with the manipulative dexterity and mechanical appliances at the disposal of the particular surgeon.

1. It is possible to utilize chipped-up fragments of living bone, either loosely powdered in the cavity to be filled, or firmly packed in. A metacarpal bone or phalanx from an amputated finger may suffice for this purpose. It is probably best to pack the cavity firmly and close it entirely; the grafts survive on account of the blood-plasma permeating through the cavity until the time arrives when the whole mass is vascularized and organized. An ununited fracture may be treated in this way by freeing the ends, and making a fresh section of them to expose healthy bone tissue; they are then fixed, *e.g.* by a plate, and the interval between the fragments packed firmly with bone chips. This is not, however, a procedure to be recommended if other means are available.

2. In some situations all that is required is a thin lamella of bony tissue—*e.g.*, in cranioplasty, or in some ununited fractures of the lower jaw. A suitable shaped flap is marked out on the front of the tibia or crest of the ilium, and the superficial layer of bone, together with the periosteum, is chiselled up and transplanted. In some fractures of the jaw a thin graft such as that described may be rolled up like a cigarette and fixed between the bone ends.

3. In other places a more massive graft is desirable, and for this purpose complete sections of bones—*e.g.*, of the fibula, or a metatarsal bone—were employed in the first place. They are effective, but not very suitable in all cases. Portions of ribs also have been used for reconstituting a lower jaw.

The introduction by Albee of the double circular saw (Fig. 292) driven by an electric motor has revolutionized this procedure, and placed in the hands of surgeons the means of cutting rapidly grafts

which are well adapted for the part they have to play. The front of the tibia is the favourite site from which to obtain such grafts for work on the long bones.

Much discussion has arisen as to whether or not a bone graft should include the periosteum, and as to its depth. There is no question that the retention of vitality of the graft depends upon its gaining a fresh blood-supply as rapidly as possible; failing this, the graft dies, and is absorbed or cast out of the body. To establish vascular continuity between the graft and the tissues in which it is placed must obviously be easier if it is covered with fibrous tissue which is vascular under normal conditions, or leaves an exposed surface of cancellous bone. Hence, whenever practicable, it is desirable that the graft should be covered with periosteum externally, and should include a portion of the vascular medullary tissue on its deeper aspect. Naturally the less the graft is handled the better, inasmuch as the superficial cells are thereby less likely to be killed.

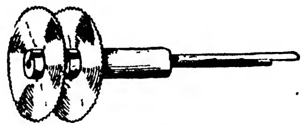


FIG. 292.—DOUBLE CIRCULAR SAW FOR BONE-GRAFTING (ALBEE). The distance between the two saws is easily regulated.

It is hardly necessary to point out that for success the following essentials must be secured: (1) *Absolute asepsis.* This excludes early operation on compound fractures, however desirable it may appear from the functional standpoint. Healing must have been secured for some time before bone-grafting is considered. (2) *Absolute hæmostasis* is necessary in order that the graft may unite rapidly with the surrounding tissues, and thus its vascular supply be ensured; the presence of a hæmatoma may jeopardize its vitality. (3) *Effective fixation* is most desirable, but if this can be secured without the use of nails, screws, or wires, so much the better; these all have a tendency to hinder reparative activity in their immediate neighbourhood; wires are less harmful than nails or screws. Autogenous bone nails or pegs are very useful, and may be cut by the shaper provided with the Albee saw outfit. (4) Complete rest must be provided after the operation, so as to permit of effective healing between the bone and the graft; too early mobilization might break up this bond of union. (5) On the other hand, as soon as union is effective, active use of the limb is desirable in order to stimulate its growth, the amount and direction of which reacts to the strain and stress placed upon the part; in other words, growth and structure depend on function.

It is impossible here to enter into details as to the various operations which may be required. It must suffice to point out three of the different methods of bone graft suitable for lesions of the long bones; others will be hinted at elsewhere.

1. The **Sliding Inlay** (Fig. 293) is a most useful method for dealing with fractures which are difficult to retain in position, or for certain ununited fractures. It consists in cutting a long narrow graft extending over both fragments (AB and BC) in such a manner that the portion derived from one fragment is double the length of that from the other. They are detached from their deep connections, and the longer (AB) is slid down so as to lie across the line of fracture; the shorter (BC) is transferred to fill up the gap left by the displacement of AB. If the grafts go down to the medullary tissue, they fit accurately, and no fixation wires or screws are neces-

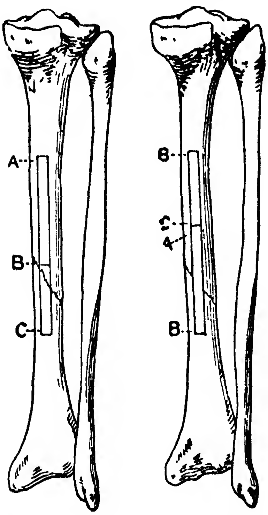


FIG. 293 —SLIDING-INLAY BONE GRAFT.

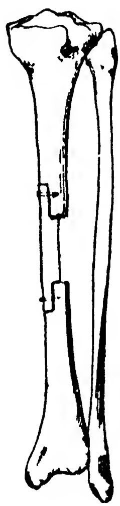


FIG. 294.—BONE-GRAFTING BY A 'STEPPED' LATERAL GRAFT.

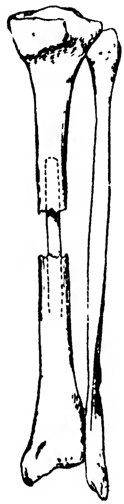


FIG 295.—BONE-GRAFTING BY AN INTRAMEDULLARY PLUG.

sary; the periosteum in such an operation is advisably stripped back, and replaced after the operation.

2. The **Lateral Graft** (Fig. 294) is employed more frequently where there is actual loss of substance. The parts are laid open; the ends of the bone are freed, and suitably 'stepped' so as to receive the graft cut from the tibia. It is laid in position and fixed by wires or bone pegs or screws, and the soft tissues closed over it. A similar plan may be adopted for ununited fractures with no great loss of substance.

3. The **Intramedullary Plug** (Fig. 295) gives fairly accurate fixation, but, as already pointed out (p. 545), it is not an altogether desirable method of procedure. There is also a considerable liability to fracture of the graft if exposed to strain too early.

CHAPTER XXII.

INJURIES OF JOINTS—DISLOCATIONS.

Sprains or strains result from sudden violence applied to a joint either directly or indirectly, and consist in tearing or stretching of ligaments or tendinous insertions of muscles close to the articular lines; in not a few instances the synovial membrane is also involved. The accident itself is very painful, and is followed by heat and swelling of the joint, due to a hæmorrhagic effusion, which with care and rest disappears in a few days, and with suitable after-treatment the joint recovers perfectly; but in the absence of the latter, recurring attacks of pain and persistent weakness are likely to develop. A neglected sprain may originate tuberculous disease or osteo-arthritis. If the patient is in a bad state of health at the time of the injury, an attack of infective arthritis may be determined.

Careful palpation to discover the most tender spot indicates the situation of the lesion, which may be at the insertion of the muscle or ligament, or at any part of its course. **Treatment** consists in putting the part to rest and supporting it firmly by a bandage over cotton-wool so as to limit effusion and to bring the segments of the divided structure into close apposition; in the more severe cases a splint should be applied. At the end of a week or ten days the splint may be dispensed with, and support secured by strapping or an elastic bandage. Massage and the alternate application of hot and cold douches also assist in restoring the function of the part, but special care must be taken to prevent stretching or injury to the newly-formed bond of union.

Thus in a **sprained ankle** the lesion commonly involves one of the fasciculi of the external lateral ligament. To bring the damaged structures into apposition, the foot is everted, and bandages or strapping must be applied so as to maintain this position, and hence must pass across the sole of the foot from within outwards and upwards. When the patient begins to get about once again, this position must still be kept up by the use of a boot, the heels and sole of which are thickened slightly on the outer side. Similarly, if the internal lateral ligament is damaged, the foot must be kept in the

varus position, and the sole and heel of the boot thickened by patches placed on the inner side.

A sprain of the **internal lateral ligament of the knee** causes tenderness over its attachment to the tibia (Fig. 313, C), and pain is specially elicited by eversion or abduction of the leg. The synovial effusion is treated in the usual way by rest in bed on a back splint, and when this has disappeared the joint must be strapped or firmly bandaged, and the weight diverted to the outer side of the limb by thickening the inner aspect of the sole and heel of the boot. Massage will, of course, be helpful, but efficient support and protection from recurrence of the mischief are even more important.

Penetrating Wounds of Joints are often accompanied by an escape of synovia, which is recognized as a glairy, oily fluid, floating perhaps on the surface of the blood; if, however, the aperture is small, this may not occur. It is always followed by a certain amount of reaction, the character of which depends on whether or not the joint is infected. If no infection has taken place, a simple synovitis ensues, but soon passes; if, however, infection has occurred, suppurative synovitis probably supervenes, leading perhaps to acute arthritis and disorganization of the joint. (For symptoms and treatment, see p. 724.) A penetrating wound, even if untreated, does not necessarily become infected; thus, if the lesion is produced by a small, clean instrument, and especially if this is inserted in a slanting direction, so that the wound is valvular, or if the incision is a large one, allowing free vent to all discharges, recovery without infection is possible.

Treatment.—If the wound is small, and there is reason to believe that infection has not occurred, the external skin should be thoroughly purified, and an aseptic dressing applied, together with a suitable splint to keep the limb at rest. A careful watch is kept upon the temperature and pulse, and also on the condition of the joint, painful distension of which probably indicates infection. The synovial cavity is then at once aspirated with a syringe and its contents withdrawn and carefully examined. (1) If the fluid is quite clear and merely blood-stained, probably no serious mischief is present. (2) If it is slightly turbid, infection is present, and the joint should be washed out with sterile saline solution, and perhaps injected with 2 drachms of a 2 per cent. solution of formalin in glycerine, or with 2 to 4 drachms of a 1 in 1,000 solution of flavine. The limb is placed on a splint with slight extension and kept at rest; for a knee-joint, a Thomas's splint should be employed. Re-accumulation of the fluid necessitates a repetition of the same procedure every day or two. (3) If the fluid is from the first frankly purulent or becomes so, a similar proceeding may be undertaken so long as the general and local symptoms are satisfactory and do not indicate any grave arthritic complications; but if the swelling of the limb increases, as also the pain and fever, then the treatment for acute arthritis (p. 725) must be instituted. (4) If the bacterio-

logical examination reveals the presence of a hæmolysing streptococcus, the chances of curing the trouble without ankylosis or amputation are much diminished.

Where the external wound is large and probably infected from the first, its treatment must correspond to that of a gunshot wound, viz., it must be carefully excised down to the lesion in the synovial membrane. The margins of the rent in the membrane are cut away, and the joint cavity washed out with sterilized saline solution, followed perhaps by ether or by the 2 per cent. solution of formalin in glycerine. The cavity is now closed, a proceeding facilitated sometimes by loosening the suprapatellar pouch from the front of the femur, and the external wound sutured or packed with gauze impregnated with flavine or 'Bipp,' with a view to delayed primary suture in a day or two.

The after-treatment of these cases is as for those of suppurative lesions of joints generally (p. 722).

Dislocations.

A **Congenital Dislocation** is one due to some irregularity of location of the bony constituents of a joint present at birth, resulting from some error of development. The hip-joint is most frequently affected (p. 495). A **recurring** dislocation is one which develops again and again on the slightest provocation or follows any injudicious movement. It is generally due to some slight irregularity in the shape of the bone end, but also to capsular relaxation, largely induced by the frequently repeated attacks of synovitis following the displacement. The shoulder and temporo-maxillary joints are most often affected.

Pathological Dislocations are produced as the result of some intra-articular affection, *e.g.*, tuberculous disease, osteo-arthritis, Charcot's disease, etc. It is unnecessary to describe them here.

Traumatic Dislocations.—The **Causes** are divided into predisposing and exciting Under the former head may be included anatomical peculiarities, such as the shallow socket of the glenoid cavity, or some muscular or ligamentous weakness. Dislocations are rare in children, since any violence directed to a joint or its neighbourhood is more likely to lead to an epiphyseal separation. Moreover, in old people the bones become brittle, and thus fractures, rather than dislocations, are produced; hence the latter lesions are almost limited to adults, and, owing to their greater exposure to injury, occur in men rather than in women.

The **Exciting Causes** are the application of external violence and muscular force, acting alone or in combination. The former may be direct, but is more commonly indirect, the force being applied at a distance from the joint. Muscular action by itself can only produce dislocation in certain joints; the head of the humerus, the patella and condyle of the jaw, are the bones most often affected in

this way. If, however, the ligaments of a joint have been stretched by previous disease or displacement, recurrent dislocations from muscular action are not unusual.

The term *complete dislocation*, or *luxation*, is applied to that condition in which the articular surfaces of the bones are completely separated from one another. An *incomplete dislocation*, or *subluxation*, is one in which the surfaces are only partially separated.

An *open dislocation* is one in which the skin has been ruptured and communication established with the external air. A *complicated dislocation* is one in which there has been some associated injury of vessels, nerves, or viscera. The term *fracture-dislocation* is one applied to a condition in which a dislocation is complicated by fracture of one or both bones involved.

The **Signs** of a dislocation are as follows: (1) The evidences of a local trauma, *e.g.*, pain, bruising, and swelling of the soft tissues, due to their laceration and the effusion of blood into them; (2) deformity, due to the articular end of the displaced bone being in some abnormal position, where it can often be felt and sometimes seen; and (3) restricted mobility of the affected joint, and hence impairment of function. The degree to which this latter phenomenon obtains is necessarily variable, but as a rule it is very marked; if, however, fracture is also present, passive movements may be possible, though associated with pain and crepitus.

The **Effects** produced by a dislocation extend to all the structures entering into and surrounding the site of injury. The ligaments are partially or completely torn; the bony surfaces are not unfrequently fractured, especially in closely-fitting hinge joints, such as the elbow and ankle; the cartilages may be bruised, or portions of them detached, and neighbouring muscles and tendons lacerated and displaced; adjacent vessels and nerves are often contused or compressed. Considerable effusion of blood is always present.

The character of the injury explains the difficulties that are met with in its reduction. (*a*) The anatomical arrangement of the joint and its ligaments results in the hitching of bony prominences against one another, whilst the head of the bone does not always lie opposite the hole in the capsule through which it originally passed. In a few cases the end of the bone may be grasped by neighbouring ligaments and tendons in such a way as to hinder its replacement. (*b*) Muscular contraction also constitutes an obstacle, which, though it can be counteracted by suitable traction, is more effectively overcome by the use of an anæsthetic. Not only does the patient maintain the limb in a condition of rest by a voluntary tonic contraction, but it becomes fixed by the involuntary passive tension of the displaced muscles.

When once reduced, there is usually but little tendency for a dislocation to recur. Reparative changes quickly manifest themselves; blood-clot is absorbed; the rent in the capsule closes by cicatrization, and in many cases no permanent lesion remains; in

some, however, the joint is left in a weak and relaxed state, and liable to a recurrence of the displacement, while intra-articular adhesions, or the cicatricial contraction of the injured ligaments and muscles, may cause some loss of mobility.

If a dislocation is *allowed to remain unreduced*, the true articular cavity becomes shallow and partly filled up by a transformation of its cartilage into fibrous tissue, whilst the displaced head of the bone becomes adherent to the structures amongst which it lies; as the result of a plastic inflammation, either dense fibrous adhesions are formed, or a new false joint (*pseudarthrosis*). The articular cartilage is eroded, and the exposed bone eburnated and sclerosed, whilst,

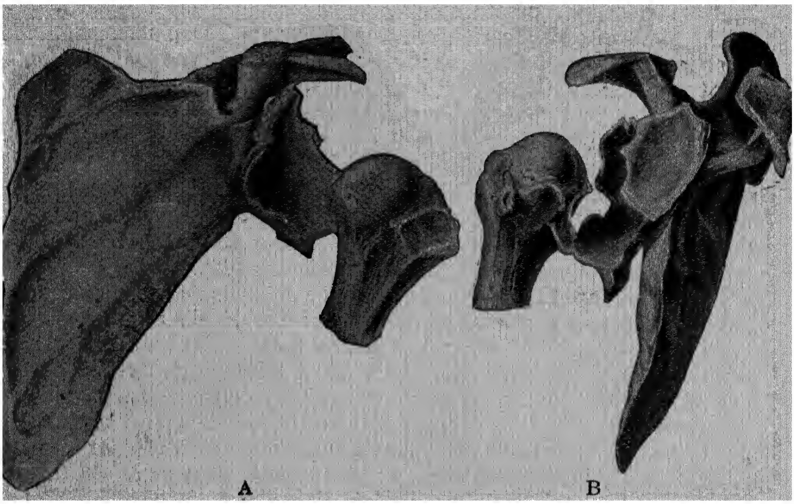


FIG. 296.—OLD-STANDING SUBCORACOID DISLOCATION OF THE SHOULDER SHOWING ATROPHY OF TRUE GLENOID CAVITY, TOGETHER WITH FORMATION OF NEW JOINT AND ALTERATION IN SHAPE OF HEAD OF BONE. (FROM COLLEGE OF SURGEONS' MUSEUM.)

owing to chronic periostitis, the end of the shaft may be considerably deformed. The portion of bone upon which the displaced head rests undergoes changes, partly atrophic (from pressure), partly hypertrophic (as a result of chronic periostitis), whereby a new socket is produced (Fig. 296). Neighbouring muscles are secondarily shortened, and accommodate themselves to the abnormal position of the limb, and tendons which have been torn gain fresh attachments. These changes necessarily interfere more or less seriously with the power of the limb and the movements of the joint. Serious pain is not unfrequently caused by pressure on neighbouring nerves.

Treatment.—The displaced bone should be reduced with as little delay as possible, and to effect this two chief methods are employed —viz., manipulation and extension.

Manipulation should always be used when practicable, less injury being sustained by the surrounding tissues. It consists in moving the limb in such directions as shall cause the displaced end to retrace the course that it has already taken, through the rent in the capsule to its normal position. The shoulder and hip joints are more amenable to this method of treatment than hinge joints. Anæsthesia will be required in difficult cases, and especially in dislocations of the shoulder and hip joints, but it is only right to draw attention to the fact that a large number of anæsthetic fatalities have been reported as occurring in the treatment of shoulder dislocations; this is due mainly to two causes—viz., the deep anæsthesia required, and the want of preparation of the patient. The greatest care

Extension is employed to overcome muscular and other forms of resistance, so as to allow the bone to slip back or be manipulated into its original position. In order to make this effectual, the parts above the dislocation are steadied by some *counter-extending* force applied either by the hands of an assistant, or by a belt or towel, or by the knee or foot of the surgeon. Extension may be made by the hands, or a firmer grip may be maintained, and greater force used, by applying a bandage or towel to the limb. In a few cases the force may be exerted through some form of multiplying pulley, fixed at one end to a hook or staple, and at the other end attached to the limb. When any such contrivance is employed, precautions must be taken to protect the soft tissues. A useful plan consists in applying a damp bandage at the point from which traction is to be made, and over this a thick skein of worsted in the form of a clove-hitch, the loop being attached to the hook of the pulley. The extension must be made continuously, and without jolting or jerking.

Reduction, however produced, is usually accompanied by a sudden and distinct snap or suction sound, due to the contraction of muscles, unless the patient is deeply under an anæsthetic, and the muscles are absolutely relaxed. The limb is subsequently kept at rest for some days, to allow the rent in the capsule to heal, but massage may be started in a day or two, and passive movements after a week.

The treatment of an unreduced dislocation is often a matter of considerable difficulty. Attempts at reduction *may* be undertaken up to two months, but the greatest caution must be employed for fear of rupturing adhesions and endangering the main vessels or nerves. Extension by pulleys has given rise to so many accidents, varying in severity from laceration of the skin to actual avulsion of the limb, that it is wise to discontinue such treatment if it has failed on its first application.

The amount of mobility in an unreduced dislocation varies much in different cases, and the character of the treatment is mainly

governed by this. If movement is tolerably free, and not particularly painful, massage and manipulation may be undertaken and a very useful limb result. Where, however, movement is both painful and limited, operative treatment is desirable. (i.) Reduction by *open operation* consists in cutting down on the head of the bone, and freeing it from adhesions to surrounding structures, the capsule of the joint being also opened and the cavity cleared; reduction may then be possible by means of manipulation or extension. A few cases of successful treatment of old-standing dislocations of the shoulder by this means have been recorded; but as a rule the improvement is scarcely commensurate with the risks and difficulties of the operation, especially if a considerable interval has elapsed since the accident. (ii.) *Excision* of the displaced portion of the bone will often give a better result. In the elbow-joint it may be the only practicable treatment, and in the shoulder and hip it is usually better than attempting open reduction.

Open dislocations are always serious lesions, for not only are adjacent vessels and nerves liable to injury, but unless efficient treatment is adopted, suppurative arthritis ensues, leading to disorganization of the articulation, with subsequent ankylosis, or, in the case of larger joints, possibly to death from pyæmia or toxic poisoning. The **Treatment** consists in applying the principles already enunciated for those of all serious lacerated wounds (p. 260). The surrounding skin is first thoroughly purified; the edges of the external wound are excised, as also any gravely damaged soft tissues; the dislocation is reduced; the deeper parts are examined, and if need be washed with an antiseptic, or 'bipped,' and the whole wound closed with or without drainage, or temporarily packed with a view to performing delayed primary suture. The bone, if much damaged, must be dealt with according to the instructions given for the treatment of open fractures, but immediate excision is probably desirable if retention of the damaged part is likely to be followed by ankylosis.

Special Dislocations.

Dislocation of the Lower Jaw forwards is not a very common accident, and usually results either from muscular action, or from a blow on the chin when the mouth is widely open, as in gaping, laughing, or attempting to take a large bite. It has also been produced in dentistry during tooth-drawing, or from digging out roots with an elevator.

The *mechanism* of the dislocation is as follows: When the mouth is opened, the condyle of the jaw slips forwards on to the eminentia articularis, and it requires very little force to displace it still further into the zygomatic fossa (Fig. 297). The interarticular cartilage follows the condyle, and the attachment of the external pterygoid

muscle to that structure and to the bone explains the occurrence of dislocation from muscular action.

The displacement may be unilateral or bilateral, more frequently the latter. The mouth remains widely open, the teeth and the jaws being separated by an interval of about an inch. The lower jaw projects, and is fixed, saliva dribbling over the lip; speech and deglutition are impaired, the pronunciation of the labial consonants being especially difficult. A hollow can be detected immediately in front of the tragus, where the condyle is normally lodged, and in front of this the condyle can be felt, being recognized by the slight amount of passive movement still possible. A finger in the mouth may define the coronoid process in an abnormal position beneath the zygoma.

FIG. 297.—DISLOCATION OF JAW.

Treatment.—Reduction is usually easy. All that is needed is to depress the condyle below the level of the eminentia articularis, when the masseter, temporal, and internal pterygoid muscles speedily draw it back into the glenoid cavity. The patient is seated in a chair; the surgeon standing in front protects his thumbs with thick napkins, and introduces them into the mouth, pressing upon the lower molar teeth. Pressure is continued in a downward and backward direction until the condyle is free, and then the chin is raised by the fingers on either side. The jaw is kept at rest for a week or ten days by means of a four-tailed bandage. Anæsthesia is occasionally necessary.

A few cases are on record of displacement of the condyle of the jaw *backwards*, associated with fracture of the tympanic plate and tearing or separation of the cartilage of the auricle, leading to bleeding from the ear. Displacement *upwards* into the cranial cavity through the roof of the glenoid fossa has also been described.

Subluxation of the Temporo-maxillary Joint is due to displacement of a relaxed interarticular cartilage, which becomes folded or nipped on opening the mouth, the result being a painful temporary fixation of the jaw, with a snap or crack on freeing it (*q.v.*).

Dislocation of the Sternal End of the Clavicle.—In spite of the apparent weakness of this joint and the great strains to which it is subjected, dislocation is uncommon, owing to the strength of the ligaments surrounding it, particularly of the rhomboid, the clavicle being more easily broken than displaced. The **cause** of these dislocations is always violence directed to the outer end of the bone, and since that usually acts from in front, the inner end of the bone is generally thrown forwards. Two other varieties are described, however, in which the displacement is backwards or upwards, but it is generally incomplete.

In the **forward** dislocation the end of the bone lies on the anterior surface of the manubrium, where it can be easily detected; all the ligaments of the joint are torn, except, perhaps, the interclavicular. The point of the shoulder is approximated to the middle line. **Treatment.**—Reduction is effected by placing the knee against the spine between the scapulæ, and drawing the shoulders backwards, the elbow on the affected side being kept in front of the mid-axillary line. To prevent recurrence, a pad of adhesive plaster, six or eight layers thick, and with the sticky side out, is carefully moulded over the end of the bone and fixed by other strips of plaster. The arm is then put up as for a fractured clavicle. No bad result follows, even if the dislocation remains partly unreduced.

The **backward** and **upward** dislocations are both extremely rare, and in each pressure symptoms on the trachea and great vessels of the neck may be produced. Reduction is effected as in the forward displacement, or by levering the inner end of the clavicle outwards by manipulating the arm over the surgeon's knee placed as a fulcrum in the axilla.

Dislocation of the Acromio-clavicular Joint consists in the acromion being forced either above or below the outer end of the clavicle, more commonly the latter. The displacement is easily recognized by the abnormal prominence of one or other of the bones. It usually results from violence directed to the scapula. No difficulty is experienced in reduction, but the displacement is very liable to recur, especially in the more common form. The elbow is then flexed to a right angle, and pads of several layers of adhesive plaster placed over the acromion and beneath the elbow; a bandage or strap, applied over the shoulder and under the elbow, suffices to maintain the bone in position. The strap is kept from slipping by passing a bandage under it round the opposite side of the chest. The arm is kept in a sling bent to a right angle. Should the displacement persist, the bones may be wired together after bringing the cartilaginous surfaces into contact, the wires being placed so as not to encroach on the joint surfaces. Either they may be passed through the bones vertically, or as a mattress suture from before backwards.

Dislocation of the Shoulder occurs almost as frequently as all the other dislocations of the body put together. The shallowness of the glenoid cavity, the size of the head of the humerus, the laxity

of the capsule, the extent and force of the movements possible, and the exposed position of the shoulder, explain the great frequency of the accident. It usually results from falls upon the hand or elbow, the arm at the time of the accident being widely outstretched. The weak lower and inner part of the capsule first yields, the head of the bone being primarily displaced downwards into the axilla (subglenoid variety), and then, according to the direction of the force, or the character of the subsequent manipulations, the head travels either forwards (subcoracoid or subclavicular dislocation) or backwards (subspinous). Falls on the elbow or shoulder may, however, cause a direct forward or backward displacement.

The **Signs** of a dislocation of the shoulder are sufficiently obvious, and certain characteristic features are present in almost all varieties.

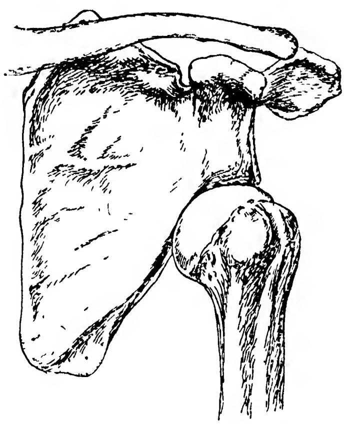


FIG. 298.—SUBGLENOID DISLOCATION OF SHOULDER.

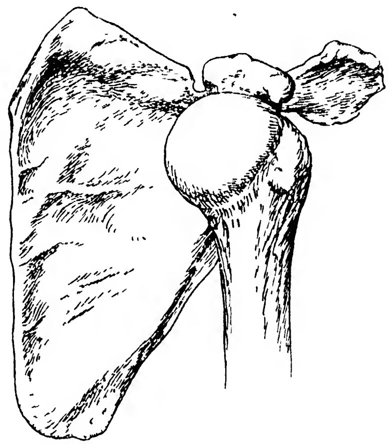


FIG. 299.—SUBCORACOID DISLOCATION OF SHOULDER.

(1) The shoulder looks flattened, owing to displacement of the head inwards (Fig. 300), and as a result of this the acromion process is unduly prominent, and a hollow is felt below it, occupied by the tense deltoid. (2) The head of the bone lies in some abnormal position, and the glenoid cavity is empty. (3) The elbow is displaced away from the side, and it is impossible to make it touch the chest wall at the same time that the hand is placed on the opposite shoulder (Dugas' test); this does not always obtain in the subcoracoid type. (4) The vertical measurement round the axilla is increased in all the varieties (Callaway's test); whilst inspection reveals a lowering of the anterior or posterior axillary fold (Bryant's test). (5) A ruler or straight-edge can be made to touch both the acromion process and the outer condyle of the elbow in most cases of dislocation (Hamilton's ruler test); this is impossible when the head of the bone is in its normal position, but can also occur in fractures of the anatomical

neck. At the same time, the usual signs of a dislocation, viz., rigidity and local bruising, are also present. Stereoscopic radiography is, of course, invaluable for diagnostic purposes.

Subglenoid Dislocation (Fig. 298) is always the primary condition when due to a fall upon the outstretched arm, but is not often seen, since further displacement usually occurs before the case comes under observation. The head of the bone passes down into the axilla, resting against the outer border of the scapula below the glenoid cavity, between the subscapularis above and the teres minor below, with the long head of the triceps behind. The capsular ligament and muscles passing to the tuberosities are torn, whilst the axillary vessels and nerves may be seriously compressed, leading to numbness of the fingers. The head of the bone is felt in the axilla, and the

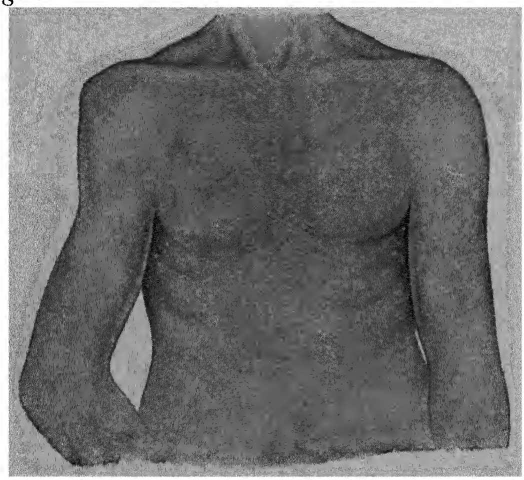


FIG. 300.—SUBCORACOID DISLOCATION OF THE RIGHT SHOULDER.

anterior axillary fold is much lowered; the elbow is directed away from the side and slightly backwards; the arm is lengthened, perhaps to the extent of 1 inch, whilst the forearm is usually flexed. The lower edge of the glenoid cavity is sometimes broken off, and then reduction with crepitus is easily accomplished, but the displacement as readily recurs.

In a few cases the arm has been abducted and displaced vertically upwards, although the head of the bone was in the usual position of a subglenoid dislocation, constituting the *luxatio erecta*.

Subcoracoid Dislocation (Figs. 298 and 299) is the most common variety. The head of the bone lies under the coracoid process on the anterior part of the neck of the scapula, immediately in front of the glenoid cavity, the anatomical neck impinging on its anterior border. In this position it lies over the tendon of the subscapularis,

which is either torn or stretched across the neck as a tense band, considerably impeding reduction. The muscles attached to the great tuberosity may be stretched, resulting in marked external rotation of the limb (subcoracoid variety), or they are torn, or even the great tuberosity itself pulled off, the humerus being then rotated inwards (intracoracoid variety). The elbow is displaced backwards and outwards, and the head of the bone can be felt on rotation of the arm under the outer third of the clavicle. Little alteration is produced in the length of the arm.

The **Subclavicular** variety is uncommon, and merely an exaggeration of the subcoracoid. The head of the humerus passes further inwards, and lies deeply under the pectoralis minor, on the second and third ribs. The elbow is markedly separated from the side and directed a little backwards, whilst distinct shortening is present.

The **Subspinous Dislocation** (Fig. 301) is unusual. The head lies in the infraspinous fossa, immediately behind the glenoid cavity, between the infraspinatus and teres minor muscles, the subscapularis being generally torn. The elbow is displaced considerably forwards, but can be made to touch the chest wall; the arm is rotated inwards, so that the hand is thrown across the front of the body. There is usually a marked hollow in front of the shoulder, whilst a prominence is caused behind by the head of the bone in its false position. The length of the arm is often unaffected, but if any change is present, it is slightly lengthened.

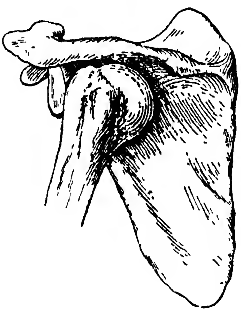


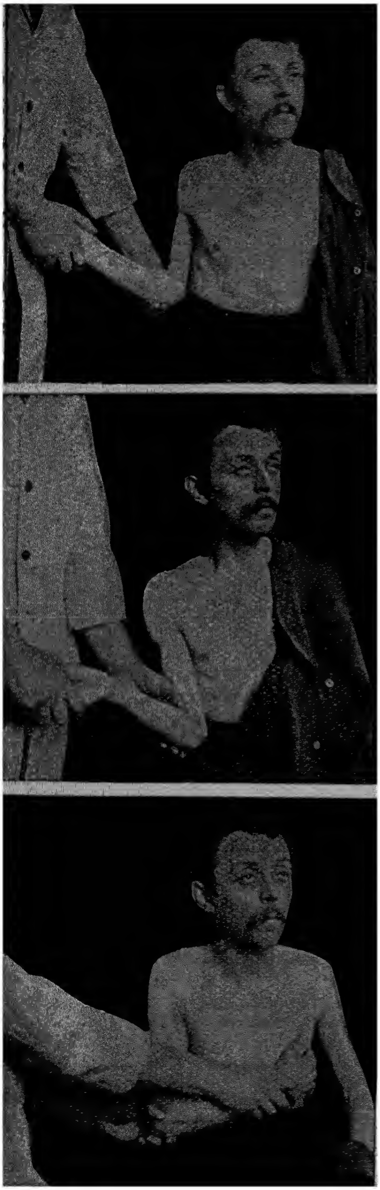
FIG. 301.—SUBSPINOUS DISLOCATION OF SHOULDER.

A few cases have been described of what is known as a **Supracoracoid Dislocation.** The head of the bone is displaced upwards, and either the coracoid or acromion process is broken, more commonly the former. Replacement with crepitus is easily obtained, but the dislocation is liable to recur.

The **Treatment of Dislocation of the Shoulder** consists in reduction by manipulation or extension.

1. For *reduction by manipulation* an anæsthetic is always advisable, but must be given with caution. Many methods have been suggested, of which the following are the more important. Not unfrequently, however, when the muscles are relaxed, any slight rotary movement suffices to 'put the bone in.'

Kocher's Method for Subcoracoid Dislocations.—The surgeon standing in front of his patient, who is seated or reclining, and supported by an assistant, grasps the flexed elbow with one hand, and by leaning on this produces slight extension. With the other hand he grasps the wrist and rotates the arm firmly and steadily outwards



FIGS. 302, 303, 304 —KOCHER'S METHOD OF REDUCTION OF A SUBCORACOID DISLOCATION OF THE SHOULDER.

as far as it will go, the elbow being pressed to the side (Fig. 302). Distinct resistance will be felt, due to the contraction of the subscapularis, which must be tired out by maintained pressure in the position described. At length the tension of the muscle gives, and this allows the head of the humerus to slip slightly downwards towards the axilla and finally to roll out beneath the acromion, and may suffice to effect reduction. If the limb is still displaced, the elbow should be drawn steadily forwards and upwards as far as it will go, with the humerus still fully everted (Fig. 303), whilst finally the arm is rotated inwards so as to carry the hand towards the opposite shoulder, and the elbow drawn across the chest and lowered (Fig. 304). All these movements should be carried out steadily and evenly, and without undue force or jerking for fear of fracturing the surgical neck of the bone.

2. *Extension* may be employed in different ways, the object being to overcome the tension of surrounding ligaments and muscles. It may be applied directly downwards by the surgeon grasping and pulling on the arm, whilst his unbooted foot is used as a counter-extending force in the axilla, the patient lying flat on a mattress placed on the ground, and the surgeon sitting by the side. Another plan consists in using the knee as a fulcrum instead of the heel, the patient sitting in a chair; one assistant makes traction on the limb abducted to a right

angle, whilst another makes counter-extension and steadies the scapula.

After-treatment.—The whole arm is bandaged to the side for a week or ten days, so as to allow the extravasated blood to be absorbed and the rent in the capsule to be closed. The arm is then carried in a sling, and gentle movements (other than abduction) permitted; flexion, extension, and rotary movements must be gradually restored and finally abduction. In three to four weeks a full range of movements should be possible in the absence of complications.

Associated fracture of the lower margin of the glenoid cavity requires more careful and prolonged fixation, so as to prevent recurrence of the trouble. When the dislocation is complicated by fracture of the great tuberosity, the head of the bone must be reduced, and the limb fixed in abduction so as to approximate the fractured surfaces. Radiography will be essential in order to test the position of the head of the bone and of the fragment; if this is unsatisfactory, open operation to fix the tuberosity by screw or bone peg must be undertaken.

Recurring or Habitual Dislocation of the shoulder is an uncomfortable condition in which the head of the bone slips out of place without sufficient cause. It is due either to irregular shape of the head, or more often to a relaxed capsule, possibly due to too early and vigorous mobilization after a traumatic dislocation. Prevention is possible if the patient can remember never to undertake certain movements—*e.g.*, hyper-abduction of the arm, as in doing the hair; but more often relief by operative measures will be acceptable. (1) It is possible to expose the capsule from the front and take in the slack, either by excising an elliptic portion, or by folding it into suitable creases, which are fixed by sutures; in many cases this will suffice. (2) A more certain result may be anticipated to follow *Clairmont's operation.** Two incisions are required back and front of the joint, exposing the anterior and posterior borders of the deltoid. Through the anterior incision the muscle is split longitudinally, and opened up so as to enable the surgeon to define and enlarge the quadrilateral space. Through the posterior incision a slip-like flap of the deltoid is detached from above, but left attached below, and its nerve-supply carefully guarded. Its free end is passed through the quadrilateral space, and sutured to the split anterior portion of the deltoid. This operation is most reliable, as the transposed flap acts not only as a sling to keep the head of the bone in place, but also tightens up when abduction is attempted.

Dislocations of the Elbow-Joint are not very uncommon, occurring particularly in young people, and are due to either direct or indirect violence. The diagnosis is often difficult from the amount of swelling that quickly follows. A careful investigation of the relative position of the bony points, and of the degree of mobility of the different parts on each other, is essential in order to arrive

* See Robert Jones and Lovett's 'Orthopædic Surgery,' Oxford Med. Pub., 1923.

at a definite conclusion as to the exact nature of the lesion. In cases of doubt a radiograph should be taken.

1. **Dislocation of Both Bones** may occur either *backwards, forwards,* or *laterally.*

The **backward** variety (Fig. 221, A, and R.S., Fig. 8) is that most often seen. If the coronoid process remains unbroken, it sometimes becomes locked in the olecranon fossa, and renders the arm immobile; if, however, it is detached, considerable mobility of both bones occurs, with crepitus. The forearm is semi-flexed, the hand held midway between pronation and supination, and the displaced bones form a considerable swelling at the back of the joint, above which is a marked hollow, crossed by the triceps. The lower end of the humerus projects in front, and the artery and the soft parts are displaced forwards. The measurement from the acromion process to the external condyle remains unaltered, but that from the condyle to the styloid process of the radius is distinctly shortened, and the distance between the condyles and the olecranon process is increased.

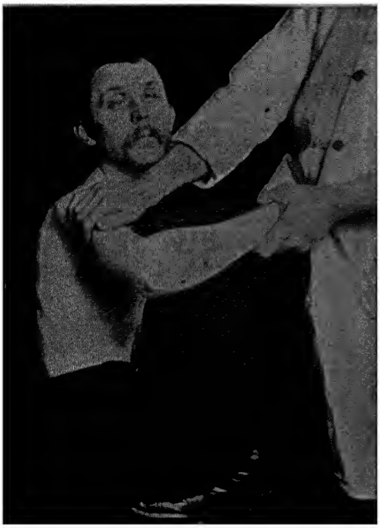


Fig. 305.—Reduction of Backward Dislocation at the Elbow.

Dislocation **forwards** of both bones rarely occurs without fracture of the olecranon, although a few cases are on record. The displacement is readily detected, the forearm being lengthened perhaps to the extent of an inch. The arm is in a condition of flexion, and, indeed, the accident can only take place from falling backwards on the point of the elbow when in this position. The triceps muscle will be considerably torn.

Lateral dislocations of the forearm are almost always incomplete, and are rare apart from fractures; the bones may be displaced either inwards or outwards, the latter being the more common. They are recognized by a careful examination of the relative position of the bony prominences and by stereoscopic radiography.

2. **Dislocation of the Ulna alone** occurs only in a *backward* direction. It is very uncommon owing to the position and strength of the orbicular and oblique ligaments and of the interosseous membrane. In a position of full pronation, however, forcible adduction of the forearm may determine this displacement without extensive

ligamentous lacerations, which, indeed, have not been noted in any of the cases observed.

In the **Treatment** of the above dislocations all that is necessary is to unhitch the interlocking bony prominences, so as to allow the bones to return to their normal positions by muscular contraction. This is usually accomplished by the method described by Sir Astley Cooper. The patient being in a sitting position, the surgeon presses backwards, with his knee in the bend of the elbow, against the lower end of the humerus; at the same time he grasps the patient's wrist, and slowly and forcibly bends the forearm (Fig. 305). The arm is bent to a right angle and kept at rest for two or three weeks at least, so as to permit repair to be accomplished perfectly, and to minimize the likelihood of a development of traumatic myositis ossificans in the substance of the brachialis anticus (p. 463), a by no means unfrequent sequela.

3. **Dislocation of the Radius alone** may occur either *forwards*, *backwards*, or *outwards*.

The **forward** dislocation (Fig. 306) is that usually seen, and results from falls on the hand when the forearm is in a state of extreme pronation, or from forcible traction upon the hand, or from direct injury applied to the back and outer side of the elbow. The head of the radius rests against the lower end of the humerus in the hollow above the capitellum, and the most characterisic feature consists in the inability of the patient to flex his forearm, owing to the bone impinging against the lower end of the humerus. It can be readily detected in this situation, rotating with the movements of the forearm, whilst a deep hollow is felt behind, immediately below the external condyle. The forearm is somewhat flexed, and midway between pronation and supination; the former act can be satisfactorily accomplished, but supination cannot be carried further than half-way. A marked fulness exists on the anterior aspect of the limb when the arm is extended. Fracture of the upper third of the ulna sometimes accompanies this accident, especially when produced by direct violence. If this luxation is not reduced, great impairment of the mobility of the limb results, flexion beyond an obtuse angle becoming impossible. **Treatment.**—Reduction is accomplished by traction from the wrist, with the forearm flexed to a right angle, combined with pressure over the head of the bone. Owing to the fact that the orbicular ligament is ruptured, the deformity is likely to recur, unless the limb is kept completely flexed in order to relax the biceps; full supination must also be maintained. Active movements of the limb must be

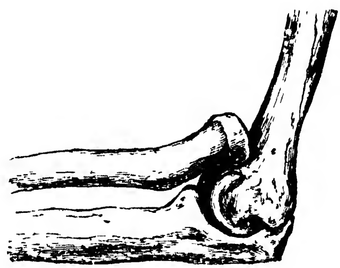


FIG. 306.—DISLOCATION OF THE RADIUS FORWARDS

interdicted for three or four weeks. In old-standing cases excision of the head of the bone is desirable.

Dislocation **backwards** is less common. The head lies behind the external condyle on the outer side of the olecranon, where it can be detected on rotating the limb. The forearm is flexed, and the limb pronated. Even if left unreduced, it leads to but little inconvenience.

Dislocation outwards is also rare, the head of the bone being displaced to the outer side of the external condyle, where it can be felt, causing considerable impairment of movement. Reduction is accomplished without difficulty, or, if necessary, the head may be excised.

Occasionally a rare form of dislocation is met with in which the ulna passes backwards and the radius forwards, resulting in great deformity.

A very common accident in children under four years of age consists in a **subluxation of the head of the radius downwards** within the orbicular ligament, so that a fold of synovial membrane slips up and becomes nipped between the head and capitellum. It results from forcible traction of the hand, as from pulling up a child roughly after it has fallen, and is a common nursery accident popularly known as **pulled elbow.** The limb becomes fixed in a position of slight flexion and with the hand pronated, and the child cries out with the pain; it is readily treated by completely flexing the limb, and subsequently extending and fully supinating it, and leaves no bad results.

It must not be forgotten that here merely the pure dislocations have been described. In actual practice **complications** of a serious nature are frequently present in the shape of fracture of one or both condyles, which add to the difficulty of diagnosis, apart from radiography, and even then the results of treatment may be unsatisfactory. Abundant callus is formed, and considerable impairment of function is liable to ensue.

Dislocation of the Wrist is a very uncommon accident, and may occur *forwards* or *backwards*. The lower ends of the radius and ulna project under the skin, and the styloid processes retain their relative positions; it is thereby easily distinguished from a Colles's fracture. Reduction is readily effected, and the hand should be kept at rest for a short time in a slightly dorsiflexed position.

Occasionally the radius, carrying with it the hand, is dislocated from the lower end of the ulna, as a result of forcible pronation, which results in laceration of the inferior radio-ulnar ligaments, and probably of the lowest portion of the interosseous membrane. The triangular fibro-cartilage is in some of these cases loosened, and its mobility may subsequently give rise to a painful weakness of the wrist. The ulna projects backwards, and its reduction is easy; but some laxity of the inferior radio-ulnar joint may persist, unless the bones are kept firmly together by suitable bandaging.

Dislocations of Various Carpal Bones have been described, and radiography has demonstrated that they are by no means uncommon. The semilunar is probably more frequently displaced than the other carpal bones. The dislocation is anterior; the bone can be felt in front of the wrist under the flexor tendons (R.S., Fig. 9). The median or ulnar nerves may be pressed upon, giving rise to pain. Excision of the bone through an anterior incision should be performed. Backward displacement of the os magnum may occur, and forms a rounded prominence under the skin which becomes more prominent in flexion, and may disappear on extension. It is, as a rule, readily reduced, but it is very likely to recur. If it is troublesome, the bone may be excised.

Dislocations of the Metacarpal Bones and Phalanges are not unfrequent, but need no special mention, except in the case of **Dislocation Backwards of the First Phalanx of the Thumb.** The chief interest here lies in the difficulty experienced in reduction, which was formerly attributed to the head slipping between the two portions of the flexor brevis pollicis and being grasped by them, as a button in a button-hole. It has now been shown that there are two much more important factors—viz., the tension of the long flexor tendon, which hitches round the neck (Fig. 307), and the arrangement of the glenoid ligament. This fibro-cartilaginous structure passes between the two heads of insertion of the short flexor muscles, and is thus incorporated between the two sesamoid bones; whilst firmly attached to the base of the phalanx, it is but loosely connected with the head of the metacarpal bone, so that it accompanies the phalanx in its dislocation, and will then be situated immediately behind the head of the metacarpal, so as to prevent reduction. **Treatment.**—Traction and manipulation are always attempted in the first instance. The thumb is grasped by a suitable apparatus and hyper-extended to a right angle, thus making the head of the metacarpal project still further through the muscular interspace, and, as it were, enlarging the button-hole. Still maintaining the traction, the thumb is rapidly flexed into the palm, the metacarpal bone being at the same

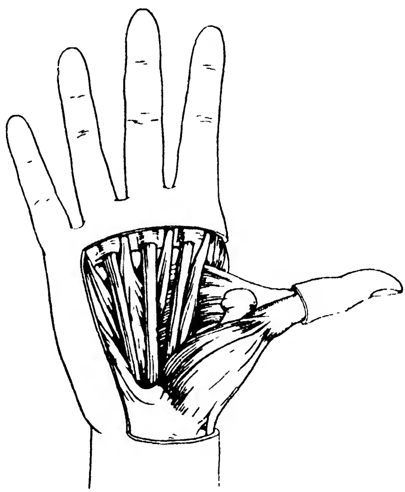


FIG. 307.—DISLOCATION OF THUMB, SHOWING HEAD OF METACARPAL BONE PROTRUDING FORWARDS BETWEEN THE HEADS OF THE SHORT FLEXOR MUSCLE.

time pressed inwards. Should this fail, as it often will, a sterilized tenotome should be inserted in the middle line of the thumb behind, immediately above the base of the phalanx, and should be pushed on till it reaches and divides the glenoid fibro-cartilage between the sesamoid bones; this little manœuvre will at once render replacement simple.

Dislocation of the Hip is fortunately not very common, as it is a condition of extreme gravity. The depth of the socket in which the femur rests, and the strength of the muscles and ligaments surrounding the articulation, explain the comparative unfrequency of the accident. It always results from violence applied to the feet or knees, or, if the legs be fixed, to the back. It is rarely met with except in young people or adults, since after the age of forty-five fractures of the neck of the bone are much more likely to occur.

Four chief varieties of dislocation are described, in two of which the head of the bone is displaced posteriorly, and in two anteriorly. The former are known as the *Dorsal* and the *Sciatic* varieties, in which the head of the bone occupies some situation on the dorsum ilii, determined by the integrity or not of the obturator internus tendon. The anterior dislocations are known as the *Obturator* (or *Thyroid*), and the *Pubic;* in the former the head of the bone is located in the obturator notch, and in the latter upon the pubic ramus. The relative frequency of these dislocations is as follows: About 50 to 55 per cent. of the cases are dorsal, 20 to 25 per cent. sciatic, 10 to 15 per cent. obturator, and 5 to 10 per cent. pubic. In addition to the above, many other slight modifications have been described, which it is unnecessary further to particularize.

Mechanism.—In considering these dislocations, the relative strength or weakness of the different parts of the capsule and its surrounding structures must be remembered. The weakest part of the capsule is placed below and behind, and it is through a rent in this position that the head of the bone most frequently escapes. In front, the ilio-femoral or Y-shaped ligament of Bigelow is a structure of much strength, on the integrity of which depends the fact whether the displaced head of the bone shall occupy some definite position or be freely movable. Bigelow, to whom we owe so much in the elucidation of the mechanism of these dislocations, has divided them into two classes—the *regular* and the *irregular*—according to whether this ligament is intact or completely lacerated. Posteriorly, the plicated tendon of the obturator internus is the most important structure, and the position and level of the bone on the dorsum ilii depend in some measure on whether it remains intact or is ruptured. It must also be remembered that the ligamentum teres is relaxed when the thigh is forcibly abducted, and is made tense by adduction.

The limb is usually in a position of *abduction* at the moment of dislocation, the head of the bone escaping through a rent in the lower and back part of the capsule. The type of accident responsible for this is a fall with the legs widely separated or when the limbs are drawn forcibly apart, as, for instance, when one leg is placed on a

boat just moving away from a pier on which the other is fixed. The direction of the violence, or the subsequent manipulations performed by willing but ignorant friends, or the voluntary movements of the individual, determine what form of dislocation will be subsequently produced. If the limb is externally rotated and extended, or the trunk is hyper-extended and the limb remains fixed, the head travels forwards, and either the pubic or obturator variety results. If, however, the leg is inverted and flexed the head of the bone passes backwards, and either the dorsal or sciatic form is produced. Again, in the posterior dislocations, if the obturator internus tendon remains intact, it may hitch across the front of the neck, and prevent any further upward displacement of the bone, thus giving rise to the so-called sciatic variety, or as Sir Astley Cooper called it, the 'dorsal below the tendon'; but if the tendon is ruptured, or if the head of the bone slips in front of it, there is no obstacle to its upward displacement on the dorsum ilii.

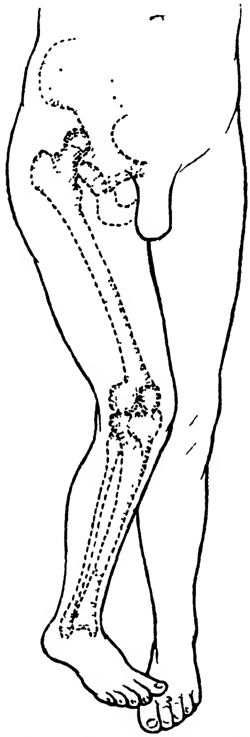


FIG. 308.—DORSAL DISLOCATION OF THE HIP.

Dislocation may also result when the limb is in a position of *adduction*, a direct dorsal dislocation being thus produced, the head of the bone escaping from the capsule above the tendon of the obturator internus; such an accident is sometimes associated with fracture of the posterior lip of the acetabulum. The type of violence leading to this occurrence is when a heavy weight falls on the back of a person whilst kneeling, or when, the knee being flexed, the body is thrust forwards, so that the limb is forcibly inverted. If, however, the thigh is in a position of extreme flexion, the head may be displaced below the tendon of the obturator internus, and the sciatic variety will then result.

1. **Dorsal Dislocation** (Fig. 308).—The head of the bone lies on the dorsum ilii, a variable distance above and behind the acetabulum, and always above the obturator internus tendon. It may be detected on manipulation of the limb, although in muscular subjects this is difficult. The ligamentum teres is necessarily ruptured, as also the capsule, the rent being situated either below or above the obturator tendon, according to whether the dislocation is due to forcible abduction or adduction. The small external rotator muscles are often lacerated, and perhaps even the glutei and the pectineus. The ilio-femoral ligament usually remains intact. The great sciatic nerve is sometimes compressed or con-

tused. The trochanter is raised above Nélaton's line (p. 603) and approximated to the anterior superior spine; the ilio-tibial band of fascia is therefore relaxed, and there is considerable shortening of the limb, amounting sometimes to 2 or 3 inches. The leg is in a position of flexion, adduction, and inversion, so that the axis of the femur crosses the lower third of the sound thigh. The knee is semi-flexed, and the ball of the great toe rests against the opposite instep; the heel is somewhat raised. A marked hollow is felt in the upper part of Scarpa's triangle, the main vessels appearing to be unsupported.

The **Diagnosis** should be easy, the only difficulty being experienced in distinguishing it from an impacted intertrochanteric fracture. The character of the accident, the presence of adduction and inversion, the increased breadth of the trochanter in the case of fracture, and the abnormally placed head of the bone in dislocation, are the points to which attention must be directed.

2. **Sciatic Dislocation,** or 'dorsal below the tendon,' is one in which the head of the bone is prevented from travelling upwards to the dorsum ilii by the integrity of the obturator internus tendon. It may occur either from forced abduction of the limb, or from extreme flexion in the adducted position. The lesions of muscles and ligaments are practically the same as for the dorsal variety. The ilio-femoral ligament is uninjured.

The **Signs** resemble those of a dorsal dislocation, but are less marked. There is less shortening, often not more than ½ to 1 inch; the limb is flexed, adducted, and inverted, but the axis of the femur is directed across the opposite knee, and the great toe rests against the ball of the great toe of the opposite side. The head of the bone is often much less distinct, owing to the greater thickness of the glutei muscles at the lower level.

FIG. 309.—REDUCTION OF DORSAL DISLOCATION OF HIP. (BRYANT.)

Treatment of the Two Backward Dislocations is effected in much the same way, whether the dorsal or sciatic variety is present. The most usual method is that of *circumduction,* so accurately worked out by Bigelow. The patient is anæsthetized, preferably on a mattress placed on the floor. The leg is first flexed on the thigh, and the thigh on the abdomen, the position of adduction and internal rotation being still maintained, so that the knee extends beyond the middle line of the body (Fig. 309). This position is maintained for some moments, and then the limb is lifted up and freely circumducted outwards, and brought rapidly down into a position of extension parallel with the other. By this manœuvre the tense structures in front of the joint are relaxed, and then the head of the bone is made to retrace its course towards

the rent in the capsule, and finally directed upwards into the acetabular cavity. These movements are tersely summarized in Bigelow's words—'*Lift up, bend out, roll out.*'

If this plan does not succeed, the following method of *traction* may be employed. The patient, lying on his back, is firmly fixed by a bandage or towel passed over the pelvis and secured to two or three hooks or staples driven into the floor. The surgeon stands over the patient, whose thigh is flexed to a right angle on the abdomen, as also the knee upon the thigh. The surgeon's arms are passed under the knee sufficiently far to enable him to grasp his own elbows, and the front of the leg is steadied against the operator's perineum. Direct and forcible traction upwards as if to lift the patient from the floor can now be made, and this is often sufficient in itself to lift the head of the bone into the acetabulum. If this is unsuccessful, the same process is repeated in a position of internal or external rotation. The above plans, combined with the use of an anæsthetic, rarely fail in reducing a backward dislocation of the hip, and hence *extension by means of pulleys* is rarely required.

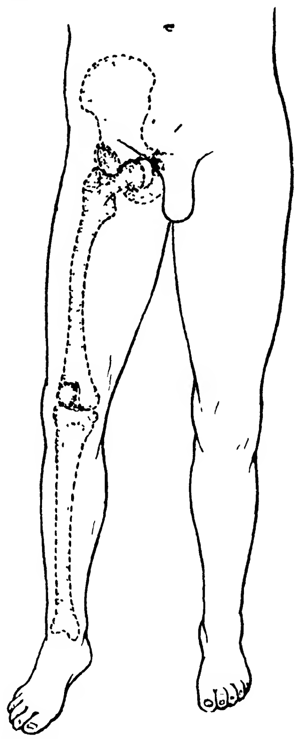


Fig. 310.—Dislocation of the Hip: Obturator Variety.

3. **Obturator (or Thyroid) Dislocation** (Fig. 310).—The head of the bone in this case passes downwards through a rent in the lower part of the capsule, and its position is subsequently but little altered, a slight forward and upward movement being alone superadded. The ilio-femoral ligament is untorn, but the pectineus and adductors are very tense, or may even be lacerated; the ligamentum teres is, of course, ruptured. The head lies on the obturator externus muscle, and can be detected in the perineum. The trochanter is less prominent than usual, and, indeed, its normal position may be represented by a depression. The limb is slightly abducted and everted, as well as lengthened, perhaps to the extent of 2 inches, though this is more apparent than real. It is also flexed, owing to the tension of the ilio-psoas muscle, and advanced before the other, with the toes pointing outwards. The adductor longus tendon stands out prominently, and much pain may be experienced from pressure on the obturator nerve. If the patient stands, the body is bent forwards, and if the dislocation remains unreduced the patient

may be able to walk without much pain or inconvenience, though in a more or less stooping attitude.

4. **Pubic Dislocation** (Fig. 311).—In this variety the head of the bone either escapes from the joint below, or may be forced out in front and to the inner side of the ilio-femoral ligament as a result of hyper-extension of the trunk. The head lies on the horizontal ramus of the pubes, just internal to the anterior inferior spinous process of the ilium, where it can be felt rolling under the finger on any movement of the limb. The vessels are pushed inwards, and considerable pain may be felt down the limb from pressure on the anterior crural nerve. The ilio-femoral ligament is untorn, whilst the ligamentum teres and capsular ligament are ruptured; the small external rotator muscles, with the exception of the obturator internus, are usually torn. There is marked flattening of the hip, the trochanter being approximated to the middle line and raised. The limb is shortened to the extent of 1 inch, and there is considerable abduction and eversion, so that the inner aspect of the limb looks forwards. The thigh is slightly flexed to relax the ilio-psoas muscle.

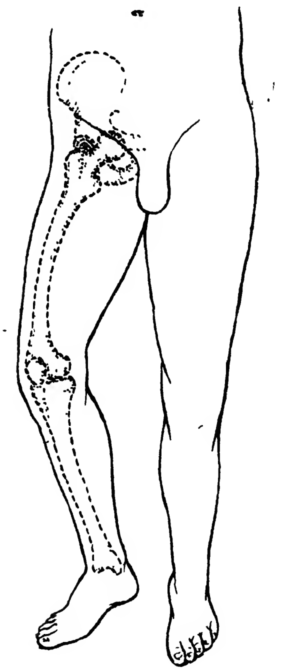


FIG. 311.—DISLOCATION OF THE HIP FORWARDS PUBIC VARIETY.

Treatment of the obturator and pubic dislocations is undertaken along similar lines as for the posterior dislocations. The patient is anæsthetized; the knee is flexed, as also the thigh upon the abdomen, but in a position of abduction; pressure backwards upon the head of the bone by the hands of an assistant will assist it in retracing its course towards the rent in the capsule. Circumduction inwards follows (Fig. 312), and on extension of the limb the head again enters the acetabulum. The obturator variety may sometimes be reduced by upward and outward traction when the limb has been flexed to a right angle in the abducted position, the unbooted foot being placed against the pelvis to steady it.

After reduction of any form of dislocation of the hip, the patient should be kept in bed with the legs tied together for about a week or ten days, and then movements, either passive or active, may be permitted, but only with great caution, and with the patient still in bed. Unless protected by a plaster of Paris spica he ought not to attempt to stand or walk for three weeks.

Should the dislocation recur, it may be due to fracture of the

posterior lip of the acetabulum, or to some involuntary movements of the patient, or perhaps to the fact that the displacement has not been fully reduced. Under such circumstances further attempts at replacement should be undertaken, and the limb subsequently kept immobilized and extended in an abduction frame for some weeks.

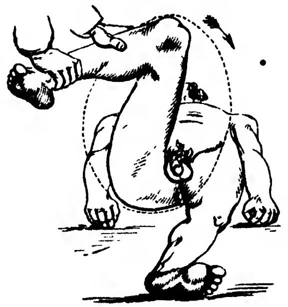


FIG. 312.—REDUCTION OF ANTERIOR DISLOCATION OF THE HIP. (BRYANT)

Dislocation of the Patella may occur *outwards*, *inwards*, or *edgeways*. A dislocation upwards resulting from rupture of the ligamentum patellæ is sometimes described, but it is scarcely to be included in the same category as the others. The displacement may be complete or incomplete; in the former, the capsule is always lacerated; in the latter, not necessarily so.

The **outward** is the only variety commonly seen, and then, on account of the obliquity of the limb, it may result from muscular action, especially in people suffering from genu valgum; it also arises from direct violence. In either case it occurs most frequently when the limb is extended, since during flexion the bone is firmly lodged in the intercondyloid notch. It lies upon the outer surface of the condyle, with its inner margin projecting forwards, and is easily felt, whilst the knee appears flattened and broader than usual, the intercondyloid notch being plainly distinguishable in the position usually occupied by the patella. *Reduction* may take place spontaneously, but is usually effected by manipulation. The thigh is flexed on the abdomen, and the knee extended, so as to relax the quadriceps, and then a little pressure on its outer margin causes the bone to slip back into place.

The **inward** dislocation is rare, being always due to direct violence. In characters and treatment it is the exact converse of those met with when the bone is displaced outwards.

A dislocation edgeways, or **Vertical Rotation** of the patella, is an interesting condition in which the bone is said to be twisted vertically upon its own axis, and even to have been turned completely round.

Recurrent dislocation of the patella is always associated with genu valgum, or with laxity of the extensor muscles from paralysis. In the former case it may be cured by correcting the deformity by means of osteotomy of the femur; but sometimes the synovial membrane of the knee-joint on the inner side will also require to be braced up by excision of a portion and suture of the margins of the defect. In this, as also in the paralytic variety, when the extensor muscle is slack, the tubercle of the tibia should be chiselled off, together with the ligamentum patellæ, and re-attached lower down.

Dislocations of the Knee may occur *laterally*, as also *forwards* or *backwards*. When due to disease of the joint, the backward dislocation is commonest; but when arising from traumatic causes, the lateral is the most frequent.

The **lateral** displacements are rarely complete, and are usually associated with a certain amount of rotation; the leg is partially flexed. Reduction is effected without difficulty.

Dislocation of the tibia **forwards** is more common than displacement backwards. It is generally complete, the lower end of the femur projecting into the popliteal space, and compressing the vessels, so that gangrene not unfrequently follows. The upper end of the tibia, carrying with it the patella, lies in front, forming a well-marked swelling with a hollow above it. There is usually considerable shortening of the limb if the articular surfaces overlap.

Dislocation of the tibia **backwards** is a much rarer accident, and is also as a rule complete. The signs are exceedingly characteristic, the pressure effects upon the popliteal vessels and nerves often resulting in gangrene.

Reduction of either of these conditions is easily accomplished by traction on the limb, whilst the thigh is flexed, combined with manipulation in order to guide the head of the tibia into its normal position. The limb must subsequently be kept at rest on a splint for two or three weeks.

Internal Derangement of the Knee-joint is so important a subject and leads to so many mistakes both in diagnosis and treatment that it must be discussed somewhat fully. The shape of the articular surfaces of the femur and tibia is certainly not such as to guarantee a stable joint, considering the severity of the strains to which it is exposed, and the freedom of movement present. The most powerful ligaments are of course attached posteriorly so as to limit extension, and the crucial ligaments are needed to assist in this check, and to prevent rotation. To serve as elastic buffers, the inter-articular cartilages are interposed, fixed to the head of the tibia, and to occupy the spare space a fatty pad of considerable size is present. It is obvious that many injuries can occur in these structures, and considerable discrimination is required if accurate diagnosis and treatment are to be effected.

1. *Ligamentous Sprains and Strains* are common, and most frequently involve the internal lateral ligament; the reason for this is obviously the mechanical disadvantage to which this ligament is exposed by the displacement outwards of the upper end of the femur to engage the acetabulum. This lesion has already been noticed (p. 683), but one would draw attention to the frequent recurrence of slight injuries to this structure with repeated attacks of mild synovitis. Tenderness is usually experienced over the extreme inner border of the tibia (Fig. 313, C), and much can be done to protect the damaged ligament by deflection of the weight to the outer side of the limb; this is effected by thickening the inner side of the heel and sole of the boot.

2. *Thickening of the Fatty Pads* behind the patella is another common source of functional disability and pain. Hæmorrhagic infiltration into this structure causes it to project backwards into the joint cavity, and exposes the free edges to the likelihood of being nipped between the bones in full extension of the joint. This in turn produces increased thickening of the pad, and the fimbriated edges become fibrous and hard, projecting into the joint cavity like the villi often seen in osteo-arthritis, and perhaps becoming adherent to the back of the joint.

The patient complains of discomfort and pain in the knee, with recurring attacks of slight synovial effusion. The chief pain is experienced in complete extension, and this is referred to either side of the patellar ligament (Fig. 313, A), where the thickened pads of fat can be felt. From time to time acute pain is experienced during walking owing to the nipping of the synovial tags, or the drag of adhesions, but there is no locking of the joint, and the synovial reaction is slight. With careful manipulation the fatty tabs and fringe can sometimes be felt rolling in the joint on movement.

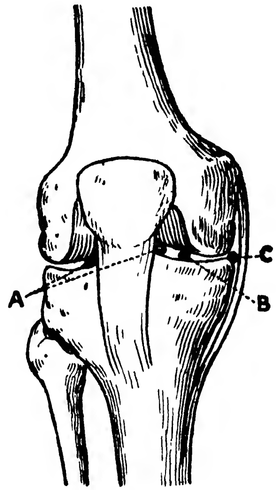


Fig 313.—Points of Maximum Tenderness in Various Conditions of Knee-Joint A, In Injury to Fatty Pads; B, In Lesions of Internal Semilunar Cartilage, C, In Sprain of Internal Lateral Ligament (Sir Robert Jones)

Treatment.—In the early stages when it appears likely that hæmorrhage has recently occurred, all that is required is rest and support by a firm flannel bandage, followed by a gradual restoration of the functions of the joint. In old-standing cases where painful limitation of movement suggests the existence of adhesions, manipulative treatment under an anæsthetic through a full range of flexion and extension may suffice to snap the adhesions and restore the joint to usefulness.

If this fail and the condition is of a chronic character, the mobility of the joint must be limited by the use of a knee cage or splint, which prevents full extension. Counter-irritation may be of some use, and massage to tone up the quadriceps, which in chronic cases is almost always atrophied; it also helps to tighten up the attachment of the subcrureus to the synovial membrane, and thus pull the fatty pad aside. Operation to remove these structures is rarely necessary, and not very satisfactory.

3. *Rupture of the Crucial Ligaments* results from twisting injuries, which are more severe than those which occasion simple sprains, and

may be accompanied or not by fracture of the tibial spine. The pain and hæmorrhagic effusion produced are so great that a diagnosis is not often made at once, except when radiography reveals an injury to the spine of the tibia. The limb is placed at rest on a back-splint, and it is only at a later date that the persistent weakness of the joint leads to a closer examination, and reveals the fact that abnormal to-and-fro movements are possible, as also perhaps internal rotation. The anatomical arrangement of the crucial ligaments is such that, when intact, inversion of the extended leg is impossible. If the anterior ligament (which is tense in extension of the leg) is torn, the tibia can be displaced forwards with the knee extended; if the posterior ligament (which becomes tense in flexion of the knee) is torn, the tibia can be displaced backwards with the knee flexed—movements which are impossible with unruptured crucials.

Treatment.—If the case is recognized fairly early, the limb is placed on a back-splint and kept at rest with a view to allowing the torn ligament to be repaired by scar tissue; the period of rest is maintained sufficiently long to permit the scar to contract and become firm. To this end a leather knee splint or cage must be used, allowing either no movement or only a very limited range; one similar to that advised for a fractured patella is useful. Operation is probably of little value, since the knee must be fully flexed in order to expose the parts, and careful approximation is in such a position almost an impossibility. The good results claimed for these operations are probably due to the effective after-treatment.

In old-standing cases with much disability Hey Groves has suggested an operation for reconstituting the crucial ligaments, utilizing the semitendinosus tendon for the posterior, and a strip of the ilio-tibial band for the anterior. In either case holes are drilled through the femur and tibia in such a direction that the new ligaments when threaded through them shall lie in the situation of the old; the loose end is fixed below by stitching. This operation has now been performed in a number of cases, and up to date has given some excellent results.

Where radiography demonstrates that the spine of the tibia is broken, an attempt must be made by manipulation and flexion of the joint to push it up into the intercondyloid notch and so prevent it from hampering movement; after-treatment is as for rupture of the crucials. Failing this manœuvre, the joint must be opened and the portion of bone fixed by a bone-nail or removed.

To open the knee-joint so as to expose the posterior parts, it is best to split or saw the patella vertically and to draw the divided halves and the split ligamentum patellæ and tendon of the quadriceps to either side; when the knee thus opened up is bent, all the posterior structures are easily accessible. The divided bone is subsequently sutured accurately.

4. *Displacement or Rupture of a Semilunar Cartilage* is a very common accident, resulting from sudden violence directed to the

knee, usually in the nature of side-slips associated with torsion; slipping from the kerbstone, injuries in mines, or falls in the football field or on the tennis court are the most frequent sources of this lesion. The close attachment of the outer margin of the cartilages to the lateral ligaments or capsule explains the causative influence of lateral strain upon these injuries; whilst in any rotary movement of the knee, only possible with the joint flexed, the pressure of the condyles always modifies the position of the cartilages, which, moreover, are relaxed and more freely movable on the upper surfaces of the tibia in flexion than in extension. The inner cartilage is much more frequently affected than the outer, and the character and extent of the lesion varies much in different cases.

The lateral ligament or capsule usually gives way first, and allows the joint to open up as a result of the leverage applied laterally upon the ankle. The cartilage then slips out from the joint, sometimes tearing the anterior or posterior attachment, more commonly the former (Fig. 314); most frequently, however, the cartilage is broken across (Fig. 315) or split longitudinally (Figs. 316, 317). The former lesion appears constantly after athletic injuries—*e.g.*, football—and involves the anterior portion of the cartilage rather than the posterior. In the latter the so-called 'bucket-handle' injury (Fig. 316) is produced in the first place, but either end of the loosened fragment may be subsequently torn, and here again usually in front, and then the handle flaps freely in the joint, and is obviously liable to cause

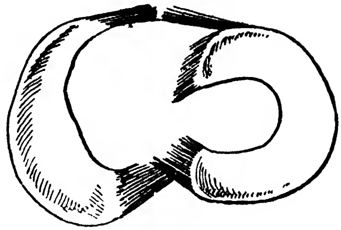


FIG. 314.

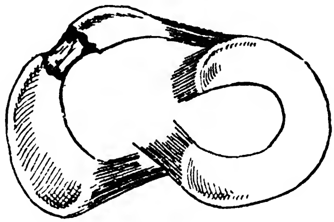


FIG. 315.

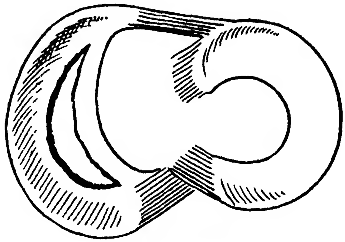


FIG. 316.

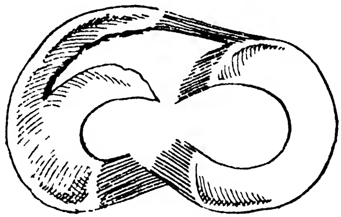


FIG. 317.

FIGS. 314-317.—DIAGRAMS OF VARIOUS TYPES OF INJURY SUSTAINED BY THE INTERNAL SEMILUNAR CARTILAGE.

In Fig. 314 the anterior attachment has been stretched and torn, and the cartilage is consequently loose. In Fig. 315 the cartilage has been torn transversely across, and a weak cicatrix has formed. In Fig. 316 the cartilage has been split longitudinally (bucket-handle injury). In Fig. 317 the anterior end of the bucket-handle has also given way, leaving a loose tag, which often causes trouble.

locking. If both ends are torn across, a loose body in the joint results. When the violence ceases, the joint surfaces come together again, and may close on the torn or displaced cartilage, fixing it and locking the joint; or the cartilage may slip back into place and give no indication of its temporary displacement beyond pain.

Repair in cartilage is always imperfect, owing to the fact that vessels only penetrate a very little way into it, and thus the free margin of a torn semilunar cartilage is a very unfavourable tissue for this process. The surfaces, moreover, become covered with endothelium, and this is a still further hindrance.

The **Symptoms** produced by this accident are a sudden sickening pain of much severity, located in the knee, which may become locked in a position of flexion, with inability to extend it. The patient may be able to 'wriggle' his joint free, or the limb may remain stiff for some hours, or even a day or two, when movement suddenly returns more or less spontaneously, a snap being at the same time felt within the joint. An attack of subacute synovitis usually follows. In other cases the cartilage remains out of place, until reduced by the surgeon, with or without an anæsthetic. The usual evidence of this is inability of the patient to extend the knee fully, any attempt to do so causing severe pain in the back of the joint, and possibly the projection of the posterior portion of the cartilage may be detected on careful palpation. Even if full reduction has been effected, the displacement is liable to recur unless sufficient time is permitted to allow firm cicatrization; otherwise the bond of union between the cartilage and the tibia, or between the severed halves of the cartilage, will be loose and elongated, permitting recurrence of the displacement, the cartilage or a portion of it slipping out of place, either externally, where it can be felt, or into the intercondyloid notch, getting nipped and locking the joint temporarily; this is followed by a mild attack of synovitis. As time goes on, this becomes more and more easy, owing to the ligaments of the joint being relaxed from the recurrent attacks of synovitis, and the limb may pass into such a state of chronic weakness as to interfere seriously with the patient's comfort. There is usually a spot of localized pain in the front of the joint, corresponding to the upper surface of the tibia (Fig. 313, B); possibly there may be some amount of lateral mobility of the leg, and movement of the cartilage may be detected on flexing and extending the knee. The quadriceps muscle is always atrophic, atonic, and relaxed.

The **Diagnosis** is often a matter of considerable difficulty, as many conditions give rise to symptoms akin to those of a displaced cartilage. Recurring *sprains of an internal lateral ligament*, due to want of prolonged fixation, are known by the absence of locking, or of the crepitus usually caused by a slipping cartilage, whilst the tender spot is over the extreme inner edge of the tibia. *Chronic traumatic arthritis* with a development of synovial fringes (p. 746) produces in certain cases symptoms almost identical with those of a displaced cartilage, except that usually there is no history of sudden onset.

The margins of the articular cartilages are usually thickened and characteristic, and the synovial villi and fringes can often be felt; the crepitus is different from that of a slipping cartilage; and the other knee may be similarly affected. The edges of the *retropatellar fatty pad* may be thickened and villus-like, and then may project backwards and get nipped between the ends of the bones. An enlarged subligamentous bursa may have a similar effect in pushing the pad backwards. The history in these cases is usually distinct from that of a torn cartilage, and the tenderness is not at the same spot. The diagnosis of a *loose foreign body* in a joint is referred to at p. 757.

Inflammation of a semilunar cartilage (*meniscitis*) also needs to be considered; it usually results from a heavy fall on the foot or heel, whereby the cartilage is bruised, painful limitation of movement results, and especially pain on standing, or straightening the knee, which is kept semiflexed; there are usually no sudden attacks of painful locking of the joint, but the cartilage is tender, and can perhaps be felt, though it is not movable.

The **Treatment** in the early stages consists in complete reduction of the displacement by manipulation, if need be under an anæsthetic. Unless the patient can extend the knee fully, some displacement persists, and subsequent trouble is sure to follow. Reduction of an internal cartilage is effected by flexing fully both the knee and hip joints; the leg is then everted fully, and abducted so as to open up the joint interspace on the inner side. A rapid movement of inversion and extension, combined with pressure on the back of the cartilage with the thumb, usually brings about satisfactory reduction, and complete extension is at once possible, and the full range of movements is restored.

The limb is subsequently kept at rest on a back-splint, and cooling lotions are applied until the inflammation has subsided; it is then further immobilized for some weeks in removable plaster of Paris or water-glass, so as to allow the lacerated ligaments to reunite and consolidate. During this period massage is employed; passive movements are permitted, followed by active movements, and movements against resistance; and finally the patient is again allowed to walk.

When the cartilage has become loose and is constantly slipping out of place, immobilization of the limb, with pressure by an elastic knee-cap, is sometimes useful. In some of the milder cases good results follow from massage and exercises applied to the quadriceps to improve its tone and tighten it up.

Should these methods of treatment fail, and the diagnosis of a torn or displaced cartilage be fairly well established, **operative treatment** is justifiable. The most minute precautions as to asepsis must of course be taken (p. 717). The patient's knee flexed to a right angle hangs over the end of the operating table, and the surgeon may with advantage sit facing it and perhaps support the foot between his knees. A curved incision sloping backwards is made by the side of the patella, or a transverse one along the upper edge of the tibia;

the extent of the superficial incision is of no importance so long as the incision in the capsule is correctly placed (Fig. 318). This is made advisably with a fresh knife (to avoid possible contamination from organisms in the skin) between the inner edge of the patellar ligament and the internal lateral ligament, which must not be encroached on. The cartilage is now exposed, and its shape and mobility readily tested by picking it up on a blunt hook slipped under its free edge. Torn and partially detached fragments are easily seen and removed, and in cases of general mobility the whole cartilage can be excised by pulling on it from the front; care must be exercised not to leave tags projecting from the divided attachments, as they may cause trouble later on. The fringes are then explored, and the other cartilage; hæmostasis is effected; and the joint carefully closed in layers without drainage. It is kept quiet on a splint for two or three days, and then gentle movements are permitted; when the wound is healed, massage and movements against resistance are instituted, but the patient should not place his weight on the limb for ten to fourteen days at least. Careful exercises to improve the muscles of the limb are subsequently required.

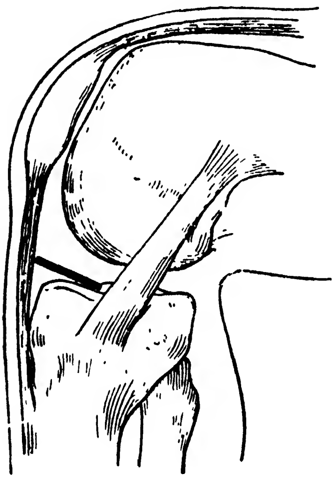


FIG. 318.—SITE OF INCISION FOR REMOVAL OF SEMILUNAR CARTILAGE, *i.e.* BETWEEN THE LIGAMENTUM PATELLÆ AND THE LATERAL LIGAMENT. (SIR R. JONES.)

Dislocations of the Ankle-joint may occur in the following directions: *outwards*, *inwards*, *backwards*, *forwards*, and *upwards*, this being the order of their frequency. Owing to the fact that the astragalus is wedged like a block into the mortice formed by the lower ends of the tibia and fibula, it is obvious that fractures of these bones are frequently met with as complications.

The **lateral** dislocations are in reality fracture-dislocations, and have been already described in the chapter on fractures (p. 626).

Although the upper articular surface of the astragalus is broader in front than behind, dislocation of the foot **backwards** is a more common accident than displacement forwards. It results from falls on the feet while running or jumping, or by sudden violence applied to the limb when the foot is fixed. Usually both malleoli are fractured, and the articular surface of the astragalus is thrown behind the lower end of the tibia. The heel projects unduly backwards, and the articular surface of the tibia usually rests upon the neck of the astragalus, the scaphoid, or even the cuneiform bones.

Dislocation **forwards** is very uncommon, and may occur without any associated fracture of the bones of the leg. The foot is apparently lengthened, and the tibia rests upon the posterior part of the upper surface of the os calcis, behind the astragalus, the prominence of the heel and of the tendo Achillis being lost.

The *treatment* of antero-posterior dislocations consists in reduction by traction. The leg is flexed upon the thigh, so as to relax the tendo Achillis, or, if necessary, this structure is divided. The ankle is subsequently commanded by a pair of Cline's side-splints, care being taken to keep the foot at right angles to the leg, and the articular surfaces of the astragalus and tibia exactly in apposition.

A dislocation **upwards** has been described in which the astragalus, together with the foot, is carried up between the tibia and fibula, owing to a rupture of the inferior tibio-fibular ligament and the lower end of the interosseous membrane, or a fracture of the tibia with displacement upwards of a wedge-shaped fragment. The deformity is very marked.

Dislocation of the Astragalus alone is by no means common. It consists in a partial or complete detachment of the bone from all its normal connections, both to the bones of the leg and of the foot, and its displacement from under the tibio-fibular arch. It may travel *backwards* or *forwards* with or without lateral rotation, and be complete or incomplete. It is frequently more or less compound.

Dislocation **forwards** is much the more common variety, and is usually associated with partial rotation, the displacement occurring more frequently outwards than inwards. When complete, the bone is entirely detached from its connections, and lies upon the upper surface of the external cuneiform and cuboid bones, the skin of the dorsum being tightly stretched over it, or even torn.

In the incomplete variety, the head of the astragalus impinges either upon the scaphoid on the inner side, or the cuboid on the outer, whilst the lower end of the tibia rests on the posterior half of the articular surface of the astragalus.

Dislocation **backwards** is almost always complete, and may or may not be associated with rotation of the bone, which can easily be felt between the tendo Achillis and the malleoli. Fracture of one or both malleoli is almost certain to accompany this displacement.

Treatment.—Reduction is only possible in the incomplete forms of dislocation. The patient is anæsthetized, the knee flexed to relax the muscles or the tendo Achillis divided, and traction upon the foot established, so as to enable the surgeon to apply pressure upon the displaced bone in a suitable direction. In the complete variety reduction is impracticable, owing to the fact that the os calcis is drawn up into contact with the malleolar arch. In such cases manipulation is useless, and excision of the bone is necessary. Comparatively little impairment in the function of the foot results from this operation.

Subastragaloid Dislocation.—By this term is meant a displacement of all the bones of the foot from below the astragalus, which retains its normal position between the malleoli. It is due to some violent

strain or wrench of the foot. Displacement may occur either forwards or backwards, but in the great majority of cases it is either *backwards and inwards* or *backwards and outwards*. The luxation is rarely complete as regards the calcaneo-astragaloid joint, but the articular surfaces of the head of the astragalus and scaphoid are completely separated, the former structure lying on the dorsal surface of the latter bone. The foot is greatly deformed, the anterior portion being shortened, the heel projecting, and the toes pointing downwards. The head of the astragalus forms a rounded globular swelling under the tense skin. In a compound dislocation of this nature examined *post-mortem*, the inner edge of the under surface of the astragalus had burst through the skin; the vessels and nerves were torn or stretched, and even when the wound in the skin had been enlarged, reduction was impossible owing to the tendons which were caught around the neck of the astragalus. In such a case removal of the astragalus would have been the only practicable treatment.

In the **inward** displacements, the foot is somewhat inverted, so that the outer malleolus is unduly prominent, and the inner malleolus is lost in a deep depression caused by the lateral displacement of the os calcis; the foot is thus in a position somewhat simulating talipes equino-varus. In the **outward** dislocations the foot is everted, the inner malleolus prominent, and the outer buried, a position of talipes equino-valgus being thus assumed. In both forms the tendo Achillis is curved, with its concavity towards the displacement. *Treatment* consists in reduction by manipulation, which is sometimes readily accomplished, but may be a matter of the greatest difficulty, probably from the tibial tendons becoming hitched around the neck of the astragalus. Section of the tendo Achillis is occasionally needed. In difficult cases excision of the astragalus may be required, and when there is much associated injury to the soft parts amputation.

CHAPTER XXIII.

DISEASES OF JOINTS.

General Considerations.—A careful study of the anatomy and physiology of joints is required in order to appreciate the many problems, mechanical and pathological, which confront the surgeon in the treatment of their diseases. Limitations of space prevent us from discussing these, but we would remind students that the exposed ends of the bones entering into a joint are covered with articular cartilages, which in young people are separated from the shafts by the intervention of epiphyses, and these protect the joint in many cases from the spread of disease from the diaphyses, but in some cases are a source of danger in that the junction cartilages are intra-articular, *e.g.*, in the hip-joint. Holding the bones together is a complicated series of ligaments, of varying strength and density, usually inserted into the epiphyses in young people, and arranged so as to resist the various forms of strain to which the particular joint is exposed. Lining the under side of the ligaments, and more or less closely attached to them, is the synovial membrane, a thick, smooth structure which secretes a glairy fluid for lubricating purposes; it extends as far as the margins of the articular cartilages. Where it is not in close proximity to the ligaments, as in the knee-joint, the interspaces are padded with fat, which may occasionally prove a source of trouble. On the inner aspect of the membrane are a number of small villi, which sometimes develop to a considerable size.

Inflammatory affections of joints are of the most diverse character, and are brought about by injury, infection, or general constitutional conditions, such as gout. The trouble may be limited mainly to the synovial membrane, constituting merely a **synovitis,** or may spread to and involve other articular structures, such as ligaments, cartilages, ends of the bones, etc., thereby constituting an **arthritis,** but there is no absolute line of demarcation between the two.

Effusion into a joint occurs in most of the various manifestations, the exudate varying with the cause. The phenomena, however, are similar in all the diverse conditions, and it would be well to note them here. *Shoulder:* The curvature of the shoulder is increased, and the deltoid expanded by a fluid swelling beneath it, which is especially noticeable at its anterior border along the bicipital groove, and sometimes posteriorly; in the axilla a painful intumescence may also be felt. These symptoms may be somewhat simulated by inflammation of the multilocular subdeltoid bursa, but the latter condition is recognized by the absence of any axillary swelling, by its not encroaching on the anterior and posterior borders of the deltoid, and by the fact that, although when the patient voluntarily moves his arm pain is produced, yet when the surgeon gently manipulates it, so as to press the head of the bone against the glenoid cavity, there may be none.

Elbow: The arm is maintained in a position of flexion and pronation; the hollows on either side of the olecranon and tendon of the triceps are replaced by soft fluid swellings, the outer of which also extends down to, and masks, the head of the radius; there is usually a little general puffiness in front of the joint. It is readily distinguished from inflammation of the olecranon bursa by the

fact that in the latter condition there is a central fluid prominence over the bone, whilst in the former the swellings are placed on either side of and above the bony projection.

Wrist: The hand is in a condition of slight flexion, and there is a general fulness around the joint, most marked on the anterior and posterior aspects, but also noticeable below the styloid processes. The tendons in their sheaths are lifted up back and front, and deep fluctuation may be detected beneath them. It is distinguished from a teno-synovitis by the facts that the swelling is limited more or less to the joint line, and does not extend up and down in the direction of the tendons; there is also no limitation of movement of the fingers, and the characteristic crepitus of teno-synovitis is absent.

Hip-joint: Effusion cannot be easily detected by digital examination. There may be a little fulness and tenderness in the gluteal region, or in the upper and outer part of Scarpa's triangle. The most characteristic feature, however, is the position of flexion, abduction, and eversion taken by the limb, whilst limitation of movement is equally marked.

The *Knee*, when distended with fluid, presents a rounded outline, in which all the normal hollows, especially those on either side of the patella and ligamentum patellæ, have disappeared. There is also a swelling corresponding to the subcrureal pouch, more marked on the inner than the outer side, and extending for 3 or 4 inches above the patella. Fluctuation can be readily detected when one hand is placed above the patella, and the fingers of the other hand compress the tissues on either side of the ligamentum patellæ below, or by alternate pressure on either side of the rectus tendon. When the effusion is considerable, the patella is felt to float, and on pressing it sharply backwards can be made to tap against the intercondyloid notch of the femur (*patellar tap*). A smaller effusion is recognised by pressing the fluid downwards from the subcrureal pouch with the knee fully extended, when the patellar tap can usually be demonstrated. Enlargement of the bursa patellæ is recognised by the swelling being central and in front of the patella, so that its outline is obscured.

Ankle: The foot is held is a position of slight equinus, and the hollows between the tendo Achillis and the malleoli are replaced by fluctuating swellings, whilst the dorsal tendons are displaced forwards, and a fluid swelling appears in front of each malleolus. Enlargement of the bursa beneath the tendo Achillis is so obviously confined to the back of the joint that it should never be mistaken for true synovitis of the ankle.

The position to be adopted in the treatment of inflamed joints is a most important matter and must be carefully noted. It may be termed for convenience the **Position of Rest,** and is such as not only gives comfort to the patient, but also ensures that if the joint should become fixed, the maximum of utility is secured for the limb. Each joint must be separately studied.

Shoulder: The arm may simply be bandaged to the side if there is but little likelihood of subsequent stiffness; but whenever ankylosis is possible, it should be fixed at an angle of about 40 degrees away from the side. This permits later of a much greater range of usefulness, inasmuch as it utilizes the scapular movements. Fixation with greater abduction than this prevents the arm being placed to the side, as there is only a limited range of scapular movement.

The *Elbow* (which of course includes the superior radio-ulnar joint) is placed on an internal angular splint and flexed to a little more than a right angle, so that the hand can be approximated to the mouth. The palm of the hand must be turned slightly upwards, *i.e.*, so that the patient can just see into it. Before allowing the joint to become fixed in this position, however, it is well to ascertain from the patient what his work is, and what position of the arm will be most useful to him, as this varies much. If both elbows are threatened with stiffness, one should be kept in a position of flexion to a little more than a right angle, the other to a little less. In a person whose occupation is clerical, it may be best to allow fixity of the left forearm to occur in a position of pronation, so as to enable him to hold papers down to the table when writing.

The *Wrist* must always be immobilized in a position of slight dorsi-flexion (Fig. 90), so as to improve the power of grasping. When possible, the fixation

should not include the fingers; if it is necessary to place them on a splint, movements must be maintained by giving them a full range each day. It is wonderful how quickly adhesions form in the small joints of the fingers and in tendon sheaths, when prolonged fixation of the fingers is associated with septic changes in the wrist or arm.

The *Hip* is best immobilized in a position of moderate flexion (35°) and slight abduction, so as to counteract the pull of the powerful adductors which are always liable to adduct and invert the limb. A careful watch must be kept on the patient's pelvis, to make sure that it has not been tilted by muscular action, so as to bring about once again a position of adduction; this warning is especially necessary in reference to children. A Thomas's splint usually suffices to secure this position, but in children a double Bryant with extension to both legs is sometimes desirable.

The *Knee* is usually kept in full extension, but there is no question that the most convenient position for permanent fixation is one of slight flexion, as this assists in mounting stairs and in sitting. A shaped back-splint will suffice in milder cases, but in the more severe a Thomas's splint is required.

The *Ankle* should be kept with the foot at right angles to the leg, and this can be obtained by placing the limb on a Macintyre or a Neville splint, or by using an external splint with a plantar foot-piece (Roughton's splint).

Finally, it must be noted that although joints are now known to possess a considerable power of resistance to infection by pyogenic organisms, yet any breach of strict aseptic precautions is only too likely to be followed by disastrous results, endangering both the utility of the limb and also the life of the patient; hence the most minute care must be taken in all **operations which involve the opening of joints.** Very thorough sterilization of the skin must be insisted on, and fingers should never be introduced into the wound. A fresh knife should be employed to open the synovial membrane, for fear that in passing through the skin the knife may have been contaminated. No antiseptics are allowed to enter the joint, as they are always somewhat irritating, and may cause a considerable synovial effusion which becomes a suitable nidus for the development of bacteria, if such happen to be present. At the conclusion of the intra-articular manipulation, the joint should be gently irrigated with hot saline solution so as to remove blood clots, and carefully closed by buried sutures, which involve *seriatim* the synovial membrane, the ligaments, the overlying muscular or aponeurotic structures, and finally the superficial parts; exact co-aptation of each of these structures is necessary if good functional repair is to be obtained free from weakness. Drainage is most undesirable, and the technique must always aim at avoiding the use of a tube; but if there has been much bleeding, it may be advisable to place a drainage-tube *down to but not into* the joint cavity for 24 hours. The limb is usually kept at rest for a few days, perhaps on a splint, and then movements are cautiously permitted, at first passive, then active, and finally active against resistance, and all these advisably before the patient strains the joint (if a knee) by bearing upon it the weight of the body. Massage to the surrounding muscles will of course be employed as soon as the wound is securely healed.

Traumatic Synovitis is the condition which follows such injuries as strains or sprains, and is characterized by an effusion of blood and synovial fluid within the joint cavity, and by pain on any movement, which stretches the injured part. The characteristic signs of effusion into the particular joint are manifested, but inasmuch as the exudate is aseptic, it is quickly absorbed, granting that the joint is kept at rest. Some of the blood which escapes into the joint clots, and the coagula may collect in the reflections or pouches of the cavity, or may become fixed to the raw tissues exposed by the tear in the synovial membrane. These coagula are not always readily absorbed, but are organized into fibrous tissue constituting adhesions which may limit the free movement of the limb.

If the condition is not treated effectively by suitable rest in the early stages, the tear in the synovial membrane may be opened up again and again, leading to recurring attacks of synovial effusion (the so-called chronic synovitis, *q.v.*) with relaxation of ligaments and increasing disability. On the other hand, too prolonged fixation may result in stiffness due to the formation of adhesions and atrophy and loss of tone of muscles. **Treatment** must therefore be a judicious combination of rest and movement. In the early stages rest must be employed for a few days in order to secure absorption of the exudate; the position of rest already alluded to must be adopted. It may not always be necessary to immobilize the joint on a splint, but at any rate it must be well supported by pressure exercised by a firm bandage over a pad of cotton wool.

As soon as the effusion has disappeared, the joint should be strapped and fixed in such a position as shall approximate and keep at rest the damaged tissues. Union will be secured in seven to ten days to such a degree as to permit of gentle active movements and a greater range of passive movement, but these must never be pushed at this stage to the point of causing obvious pain. Practitioners must remember that one full range of movement up to the limit of painlessness in the course of the day is all that is required to ensure against subsequent stiffness; repeated ' sawing ' movements of a joint only irritate it, and may do harm rather than good by stretching unduly or tearing the new bond of union. Patients should never be allowed to place any strain on a limb after an attack of synovitis without support; this may be given by elastic pressure, or by a crepe bandage over cotton wool. Massage is useful to maintain the tone of the muscles and to assist in the absorption of the exudate, but must be employed with discretion, and cannot take the place of active exercise. Should the effusion persist, assistance may be gained by the alternate applications of hot and cold water, and by rubbing with stimulating embrocations.

Pyococcal Infection of Joints.

It is now well recognized that most cases of acute synovitis of joints are associated with the presence of pyococci, which are derived from the blood. It has also been abundantly shown that penetrating wounds associated with the presence of pyococci are not invariably destructive, and rightly handled there is much defensive power in the synovial membrane. On the other hand, if the inflammatory trouble progresses beyond certain limits, it results in the gravest destructive manifestations and threatens both life and limb. It is obvious that the pyococcal infection of a joint may result in many types of inflammatory trouble, but for descriptive purposes it is convenient to describe three varieties, which may be merely stages in one case, or to which the trouble may be limited.

The **organisms** present vary necessarily with the cause. Non-penetrating wounds are likely to be infected by some particular

organism derived from elsewhere in the body—*e.g.*, it may be secondary to pyorrhœa, or be dependent on gonorrhœa. In many cases it is impossible to find the causative lesion, although one looks for it carefully. In penetrating wounds (nails, knives, gunshot wounds, etc.) the infection is often of a mixed type, and in military work anaërobes are often present. Of particularly grave prognosis is a hæmolysing streptococcus.

I. Acute (Non-Suppurative) Synovitis.

In this affection the inflammation is limited almost entirely to the synovial membrane, the ligaments and other structures of the joint being but little affected. It is sometimes attributed to cold or injury, the organisms reaching the joint from the blood, as is also the case in the milder pyæmic and gonococcal affections, and some so-called cases of rheumatism.

Pathological Anatomy.—Acute synovitis is characterized by hyperæmia of the synovial membrane, and exudation of plasma and leucocytes firstly into the substance of the membrane, causing it to be thickened and spongy, and subsequently into the joint; the endothelium also proliferates, and is shed. In the early stages the effusion consists of synovia, diluted with blood plasma, and often discoloured with blood in traumatic cases, and hence on removal is sometimes spontaneously coagulable; after a time the plasma may coagulate, depositing lymph upon the articular surface, whilst serum remains. This lymph may either be removed by a natural process of absorption when the inflammation comes to an end, or it may become organized, so as to form adhesions, which consist of loose fibro-cicatricial tissue containing a few delicate bloodvessels and covered with endothelium from adjacent serous surfaces. In some varieties, especially if repair is not quickly established, a certain amount of perisynovial inflammation follows, resulting in congestion, infiltration, and perhaps relaxation of the ligaments.

The **Clinical Signs** of acute synovitis consist in the joint becoming painful and distended, and in the case of superficial joints hot to the touch and even red. The limb is maintained by muscular spasm in that position which gives the most ease—viz., that in which its capacity is the greatest, and this is usually one of slight flexion. If the condition is neglected, the flexion may increase considerably, and the limb become more or less fixed in an undesirable position, whilst the muscles governing the movements of the joint undergo rapid atrophy. The phenomena resulting from effusion into various joints have been already noted (p. 715).

When the acute stage has passed, the joint is usually left in a weak and relaxed condition, with a little passive effusion, or perhaps some adhesions. The adhesions which follow acute synovitis are usually slight in character if the case has been properly treated, and extend between opposing surfaces of synovial membrane or bone. The characteristic signs of such a condition are definite limitation of movement in some particular direction, and possibly

a little soft crepitus; no pain is experienced until tension is put on the adhesion.

The **Treatment** of acute synovitis consists in immobilizing the limb in the position of rest (p. 716); and necessarily, in all severe cases, the patient must be confined to bed. In the early stages cold should be applied to the joint by means of evaporating lotion, an icebag or Leiter's tubes, but this is not advisable in old people; in the later stages fomentations give greater relief. When the distension is considerable, removal of some of the fluid by a carefully purified aspirator or syringe will diminish pain and hasten recovery. Such fluid should always be examined bacteriologically, and if organisms are found the joint should be washed out with normal saline solution and treated as described below (p. 722) In not a few cases of acute synovitis the induction of passive hyperæmia by the application of an elastic bandage will give relief and hasten repair.

In the subacute stage, when the joint is weak and relaxed, massage or friction with stimulating liniments should be employed, whilst in the later stages elastic pressure is often of the greatest value. If the case has been neglected and the limb has assumed a vicious position, the patient should be anæsthetized and the deformity corrected; or gradual extension is made by means of a weight and pulley until a correct position is attained.

If the movements of the joint are limited by the presence of **adhesions**, these must be broken down under full anæsthesia. It is not always easy to select the cases which require this treatment, and in which it will be beneficial. In this connection the following points should be remembered: 1. Limitation of movement due to a general arthritis, however mild, is characterized by pain in every direction; with adhesions suitable for breaking down there is a certain degree of painless movement, and pain only commences when this is exceeded, and the adhesions are stretched. 2. Massive adhesions, such as those which form after serious inflammatory trouble, hold out little prospect of improvement by wrenching (except for the correction of deformity), as the divided surfaces have to heal, and in so doing fresh adhesions form. 3. The time for breaking down adhesions is as soon as possible after the inflammatory trouble has ceased, as evidenced by cessation of pain and reduction of swelling. Delay only means increased strength of the adhesions, and increased atrophy and want of tone of muscles. 4. The actual breaking down of the adhesions should be accomplished by steady force, and not by intermittent jerks. In the less serious cases, a full range of movements should be aimed at from the first, and the freedom of all movements of the joint should be tested. In the graver cases it may be desirable not to do too much at a time, as a good deal of reaction often follows; the manipulation may be repeated more than once. 5. When it is likely that a good deal of force will need to be employed, it is wise as a precautionary measure to place splints on the limb above and below the joints, since it is

not difficult to break one of the bones. 6. The joint is kept at rest for a day or two after the manipulation, but once at least each day the limb should be put through a full range of the movements secured. 7. As already pointed out, no attempt should be undertaken to break down adhesions in a joint in the neighbourhood of septic sinuses; intra-articular hæmorrhage followed by suppuration is only too likely to follow.

II. Acute Suppurative Synovitis (or Empyema of Joint).

This condition is in reality merely a further stage of that just described; the effusion becomes at first turbid by the admixture of pus cells with the synovial exudate, but finally it becomes frankly purulent. For a time it is quite possible for the suppurative process to be limited to the synovial membrane with a certain amount of perisynovial infiltration, but no true spread beyond the capsule or destruction of the articular cartilage. This stage proves most amenable to judicious treatment; but it is not uncommon to see cases of this type run over into an acute destructive arthritis, sometimes as a result of mismanagement, at others in consequence of the virulence of the causative organisms.

Causation.—(i.) Every septic penetrating *wound* of a joint passes through a stage of suppurative synovitis, and if hæmolyzing streptococci are absent, if the patient's resistance is fairly good, and if he is correctly treated, the condition may not progress beyond this. This statement is equally true of post-operative infection. (ii.) It may arise in a manner exactly analogous to that in which acute infective osteomyelitis is produced, viz., by *auto-infection.* A slight injury (*e.g.*, a sprain or strain occurring in a weakly child, convalescent from measles or scarlet fever) may result in this affection, which is then commonly due to the pneumococcus. Traumatism in a patient riddled with sepsis, *e.g.*, the breaking down of adhesions in a joint, particularly if in the neighbourhood of septic sinuses and diseased bone, is almost certain to be followed by suppuration in the joint which becomes distended with blood and pus. (iii.) It may be produced by the lodgment of a pyæmic *embolus*, and in a similar way it not unfrequently follows as a sequela of fevers, such as enteric or pneumonia, by direct transmission of some infective material. (iv.) It is sometimes met with as a result of *gonorrhœa* (p. 729). (v.) It may be lighted up as a result of the *extension* of inflammation from the end of a neighbouring bone, or from the bursting of a subcutaneous or bursal abscess into the joint. Acute arthritis of the hip-joint is sometimes due to the former of these conditions, being consecutive to an acute infective osteomyelitis of the upper end of the femur.

The **clinical signs** are merely those of a hyperacute synovitis. The joint is swollen and distended with fluid; it is hot to the touch and tender; movements, even the slightest, are often extremely painful; and sleep becomes difficult, as the relaxation of muscles

associated therewith means a change of position of the limb, which involves pain and wakes the patient. There is almost always a certain degree of pyrexia, though usually not excessive.

The **Treatment** of these cases is based on the recognition of the protective and defensive power inherent in the synovial membrane if correctly handled; in other words, the synovial membrane conforms in its reactive power to that of other serous membranes, such as the peritoneum and pleura. To be effective, treatment must be early, and the essential elements are to remove the exudate, to irrigate the cavity, perhaps to introduce some antiseptic, and to close the joint once again, trusting to the membrane to do its own defensive work. The limb is of course suitably immobilized, and slight extension applied.

The removal of the exudate may be effected by a syringe or by trocar and cannula but it is probably wiser in most cases to cut down on and expose the synovial membrane, which is then picked up by tissue forceps and opened sufficiently to give exit to the discharge, and to enable a small tube or catheter to be introduced for irrigation purposes. The knee is approached from either side, but preferably from the outer; the shoulder joint from the front along the bicipital groove; the hip from the front between the tensor fasciæ femoris and rectus muscles; the ankle from either in front of or behind the malleoli, avoiding carefully the tendon sheaths; the elbow by the outer side of the triceps tendon.

Irrigation of the joint cavity must be effective; normal saline solution is all that is necessary, but some surgeons prefer an antiseptic, such as flavine (1 in 1000) or Dakin's solution. If any fluid is to be left in the joint, either a 2 per cent. solution of formalin in glycerine (Murphy) or a 1 in 1000 solution of flavine should be employed; about one ounce of each will be required for a knee-joint. If the effusion recurs, this process may be repeated more than once.

Under no circumstances must a drainage tube be introduced into a joint in this condition; it is certain to determine ankylosis, and the surgeon's aim and object is to secure a moveable joint

The limb is placed in the position of rest, but some slight extension is applied so as slightly to separate the articular surfaces and thereby limit pain as well as check muscular spasm. The extension must be only slight, as the ligaments are always liable to be softened to some degree and may become relaxed. In dealing with a knee, for example, an adhesive plaster extension is applied to the limb under an anæsthetic; the joint is opened, irrigated, and, if thought desirable, injected. A Thomas's splint with side-bars hinged opposite the knee is put on; suitable extension is arranged, and the splint is suspended from a Balkan frame.

The great majority of cases treated in this way will quiet down; the temperature falls; the pain diminishes, and the swelling disappears. The surgeon must now turn his attention to *mobilization* of the limb. If this is undertaken rashly and too rapidly, the joint 'flares,' indicating that the bacteria in the joint are not destroyed,

but merely that their activity is suspended; any injudicious stimulation gives them a fresh opportunity for evil.

When the inflammatory trouble has apparently ceased, the knee is cautiously and gently bent to an angle of about 10 degrees, and the extension replaced; if there is no reaction, a larger range is given on the following day, and still more day by day. After about a week the hinges of the splint are daily relaxed for a time, and the patient permitted and encouraged to move his knee actively within limits which can rapidly be increased; often in three to four weeks a full range of movement is possible. Massage of the muscles of the limb will assist in this restoration of function.

Not unfrequently, however, a joint 'flares,' even after a slight degree of movement cautiously regulated. It is then kept at rest for a day or two, and the inflammatory reaction will probably subside; possibly the patient's general condition will be improved by this attack, which is in reality an auto-vaccination. The next time movement is allowed the reaction will probably be less, and then the ordinary course outlined above may be followed out.

Should the patient come under observation late, or should irrigation fail to check the inflammatory trouble, or should the 'flare-up' after a preliminary or late movement be severe, more active measures must be taken if an acute destructive arthritis is to be prevented. Free incisions must be made into the joint so as to give satisfactory drainage—*e.g.*, for the knee an incision on both sides of the patella upwards to lay open the suprapatellar pouch; for the elbow, on either side of the olecranon tendon; for the shoulder, along the bicipital groove. Here, too, the rule must be adopted—*No drainage-tube in the joint.* The incisions are left widely open, and the joint cavity irrigated occasionally; the essential element is to urge, and if need be coerce, the patient into moving the joint actively, however painful it may be. No means of drainage is more effective than active movement, which squeezes out the pus from the synovial cavity. After a short time the movements become comparatively painless; the joint heals up, and movement is retained. There is no doubt as to the value of this method in cases of suppurative synovitis.

Of course, when the inflammatory trouble has ceased and the wounds have healed, the patient is not allowed to put weight or strain on the joint without suitable support or until the muscles have been restored to tone by massage and re-educational exercises.

III. **Acute Suppurative Arthritis (or Acute Pan-Arthritis).**

In this condition the inflammatory process involves all the elements of the joint, synovial membrane, ligaments, cartilages, and bones, and may spread widely along muscle planes or along the medullary cavity. It is associated with great suffering and constitutional disturbance, and endangers both life and limb.

For **Causation,** see p. 718.

Pathological Anatomy.—The *synovial membrane*, at first merely infiltrated and hyperæmic, soon becomes converted into granulation

tissue, exuding an abundance of pus. The organisms spread through the perisynovial cellular tissue to the *ligaments*, which become sodden and relaxed by the presence of a sero-plastic exudate between the fibres, rendering them soft and œdematous, so that the tonic contraction of the muscles easily stretches them and brings about displacement. The *articular cartilages* are disintegrated and destroyed in various ways according to the acuteness of the inflammation and the amount of pressure to which they are exposed. In acute cases they early lose their normal bluish-white appearance, and become opaque and slightly yellow. The central parts, which are exposed to pressure between the ends of the bones, soon disappear, possibly by the activity of the tryptic ferment in the exudate, whilst the peripheral portions are eroded by the overgrown granulation tissue developing from the synovial membrane. When once the cartilage has been perforated at any one spot, the suppurative inflammation spreads along its under surface, stripping it from the bone, and thus inducing necrosis, as a result of which isolated portions of dead cartilage may be found lying in the joint. The *interarticular cartilages* are affected in a very similar manner, and quickly disappear. The *ends of the bone* pass into a condition of acute osteitis, resulting in the transformation of the medulla into granulation tissue, absorption of the bony cancelli, with or without suppuration, and sometimes necrosis of small portions of the cancellous tissue (*caries necrotica*). The veins within the cancelli become thrombosed, and hence pyæmia may result. The *periosteum* covering the ends of the bones is also inflamed and hyperæmic, in consequence of which spiculated or stalactitiform osteophytes are produced (Fig. 319). The *muscles* in the neighbourhood of the joint undergo rapid atrophy and fatty degeneration.

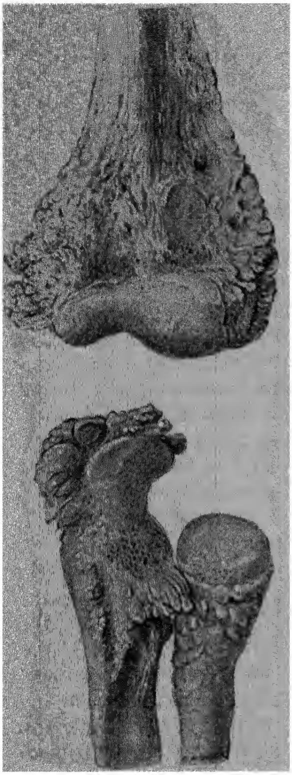


FIG. 319.—ENDS OF THE BONES AFTER ACUTE ARTHRITIS OF ELBOW, SHOWING THE CARIOUS SURFACES DEVOID OF CARTILAGE, AND THE DEVELOPMENT OF STALACTITIFORM OSTEOPHYTES. (FROM KING'S COLLEGE HOSPITAL MUSEUM.)

Course of the Case.—In the early stages acute arthritis manifests itself as a hyperacute synovitis, combined with severe pain and fever. The pain is often so intense that the patient cannot bear the part to be touched or the bed shaken, and, indeed, the slightest jar of the

limb is so exquisitely painful that the patient may scream with agony. The joint itself is distended with a turbid effusion, which rapidly becomes purulent, and the tissues around are hyperæmic and œdematous. The patient naturally places himself in that position in which the limb obtains the greatest ease, and therefore usually semiflexes the joint and fixes it by muscular contraction.

As the disease progresses, the tension within the capsule increases, until in time it yields, and the pus either travels directly to the surface, or burrows deeply into the substance of the limb, and spreads along the muscular planes; thus, in the knee an enormous abscess may collect beneath the vasti muscles, stripping them from the bone for a considerable distance. The pain increases whilst the abscesses are forming, and becomes especially distressing at night, the patient being often waked by a painful start just as he has fallen asleep. This condition usually indicates that the articular cartilages are becoming affected, and is explained by the fact that just as the patient loses consciousness, the muscles which fix the joint are relaxed, and allow the inflamed surfaces to shift their position slightly, exciting severe pain and a sudden spasmodic contraction of the muscles. Gradually the deformity becomes more and more obvious, whilst the infiltration and relaxation of the ligaments sometimes allow of abnormal movements—*e.g.*, of lateral mobility in the knee-joint; the ends of the bones become carious, and absolute displacement or dislocation may follow. Sinuses may open in all directions, and the patient suffer from recurrent rigors, caused by toxæmia or the onset of pyæmia. The constitutional effects are always severe, consisting of high fever, and rapid exhaustion from the pain, sleeplessness, and absorption of toxins.

The *terminations* of this affection are as follows: (*a*) Recovery, rarely with a moveable joint, and then only after early and active interference; in most cases ankylosis in a good or bad position, according to the treatment, is the best result that can be expected. (*b*) During the acute stage the patient may die of pyæmia, or acute toxæmia and exhaustion. (*c*) If he survive the acute stage, chronic suppuration may ensue, and symptoms of hectic fever and amyloid degeneration of the viscera may supervene. In such cases sinuses leading down to carious bone exist, and, unless efficient measures are taken to drain the parts or to remove the diseased structures, perhaps by amputation, the patient is likely to die from exhaustion or chronic toxæmia.

The **Treatment** already described as suitable for a suppurative synovitis is initiated in the first place. The limb is immobilized in the position of rest (p. 716); extension is applied to keep the inflamed bone ends apart, but with as little force as possible, so that the infiltrated and softened ligaments shall not be unduly stretched; suspension of the limb is also most necessary. If irrigation fails to check the inflammatory process, and increasing œdema of the peri-articular region and limb indicates that the trouble is extending, the joint must be laid open and free drainage secured.

Small incisions with a view to introduce drainage tubes are of little value; long incisions opening up the whole joint cavity must be employed. When all hope of gaining a moveable joint has disappeared, drainage tubes or strips of rubber glove may be employed, or continuous irrigation utilized; the Carrel-Dakin treatment is sometimes valuable in this connection. A keen watch must be kept on all aspects of the limb, so that the development of fresh abscesses may be detected and treated at once. A vaccine may possibly be prepared from the pus and administered. The fixation of the limb is carefully maintained and the general condition attended to. Irrigation continues until all signs of inflammation, heat, pain, and all startings of the limb, have passed away. The wounds are then allowed to granulate and the limb to consolidate. Chronic sinuses may persist for a time, leading to undrained pockets of pus or to diseased bone, which must be dealt with in an appropriate manner.

Excision is occasionally required early in the case in order to secure effective drainage, as in the shoulder, or more generally, at a later date, to prevent or remedy faulty ankylosis, or to place the limb in a good position; it is also sometimes used in cases of chronic suppuration with caries of the ends of the bones and displacement, but as a rule this is deferred until the wound has healed and all active trouble ceased.

Amputations may be needed for severe toxæmia or pyæmic symptoms threatening life, or for exhaustion from chronic sepsis, or for hopeless deformity.

Acute Arthritis of Special Joints.

In the **Shoulder,** infection sometimes occurs through the axilla where the capsule is weak and easily invaded by organisms, as after an axillary cellulitis; more frequently it follows a penetrating injury. Severe pain is caused by any movement of the arm affecting the joint, and if abscesses form, they will come to the surface in front of or behind the deltoid, or in the axilla. It may suffice to open the articulation anteriorly, and irrigate it; but, if necessary, a counter-opening should be made behind by cutting down on a pair of dressing-forceps pushed backwards through the capsule. In many instances the patient's condition will not improve until the head of the bone has been excised, and then the subsequent results as regards movement and power of the arm are, on the whole, satisfactory.

In the **Elbow,** there are no points requiring special mention as to clinical history or results, although it must be remembered that the superior radio-ulnar articulation is necessarily involved, and hence the power of pronation and supination of the hand is threatened. As to treatment, incisions should be made on either side of the olecranon, the ulnar nerve being avoided. The limb is then placed on a rectangular splint (*e.g.*, Sir R. Jones' flexed arm splint), which permits of extension; the hand is placed midway between pronation and supination. In an adult excision may be undertaken as soon as

the acute stage has passed, in order to obtain a moveable elbow; but in children, where the growth is incomplete, it is better to allow ankylosis to occur, and excise, if need be, at a later date.

The **Wrist** may be infected secondarily to septic conditions following operations on ganglia in the neighbourhood or through direct injury. The essential treatment consists in free incisions parallel with the tendons, and avoiding the sheaths. Ankylosis usually results, and excision is not resorted to except when the disease has become very chronic, with extensive caries of the carpus (R.S., Fig. 28).

Acute arthritis of the **Hip-joint** is usually a sequela of acute infective osteomyelitis attacking the upper end of the shaft of the femur, and involving the joint, owing to the epiphyseal cartilage being intracapsular; it also results from pyæmia, and from penetrating injuries which in civilian life are rare. The symptoms are similar to those of the first stage of ordinary tuberculous disease (p. 764), but much more acute. There is high fever, together with intense pain, marked flexion and eversion of the limb, early suppuration, and rapid disorganization if not properly treated; indeed, where nothing is done, and the patient lives long enough, the head of the bone may be entirely absorbed, or is detached, and remains as a sequestrum in the disorganized articular cavity. As soon as the capsule gives way, the pus may come to the surface in any of the usual localities for hip-joint abscesses, and the limb then becomes inverted and adducted; spontaneous dislocation follows, and the head of the bone, or what remains of it, travels upwards and backwards on the dorsum ilii. In treating these cases, the joint should be freely laid open in the situation which appears most favourable. The anterior incision is more suitable for the early, and the posterior for the later, stages, when the head of the bone is either dislocated, or remains *in situ* and separated from the shaft. A double opening may sometimes be utilized with advantage.

The **Knee-joint** is more frequently involved by this disease than any other, and is usually infected from without. The symptoms are exceedingly typical: the pain is very acute, and the joint hot and distended to its utmost capacity, the limb lying semiflexed and on its outer side. Left to itself, the capsule gives way, and suppuration rapidly extends upwards beneath the vasti, giving rise to large abscesses, which ultimately find their way to the surface. The deformity gradually increases, until in the worst forms the tibia slips behind the condyles of the femur, the leg is flexed to a right angle and rotated outwards, and if the limb has long rested on its outer side, considerable lateral displacement may also occur. Early and efficient treatment (p. 722) will usually prevent such a disaster. If this fail, the joint should be freely incised on each side of the patella, so as to open up the subcrureal pouch, and the whole articular cavity well washed out. In severe cases counter-openings must be made behind so as to drain the posterior pockets of the synovial cavity. A sinus forceps is introduced from the front and passed

backwards on either side so as to project posteriorly, and the point then cut down on. Possibly a drainage-tube may be employed with advantage, reaching as far as, but not projecting into, the synovial cavity. The nerves and tendons of the popliteal space must of course be carefully guarded. In these severe cases it may be wiser, however, to lay the joint freely open from the front by a wide U-shaped incision, dividing the ligamentum patellæ and turning up that bone. By flexing the leg completely, the femoral condyles can be exposed sufficiently to enable their posterior rounded ends to be removed by a vertical saw-cut. Plenty of room is thereby secured for the insertion of drainage-tubes from either side or for irrigation purposes. The anterior flap can be replaced and sutured in position.

When the **Ankle-joint** is involved, amputation has often to be resorted to, in consequence of the difficulty of securing good drainage, although excision of the astragalus will sometimes cut short the disease and lead to a good result.

Special Forms of Synovitis and Arthritis.

Pyæmic Synovitis is due to embolic infection from some suppurating focus. The joint becomes rapidly distended with pus, and often without pain. If the joint is promptly tapped or opened and irrigated, it usually does well, at any rate if the patient's vitality is fairly good; but if treatment is delayed, disorganization may follow (*vide* Pyæmia, p. 98).

Typhoid Disease of Joints occurs either as a synovitis or arthritis, and is due to a blood infection with the *B. typhosus*, either alone or in conjunction with pyogenic organisms. If purely typhoid in type, suppuration does not occur; there may be a mild synovitis in several joints, or a marked effusion in one followed by relaxation of ligaments, so that spontaneous dislocation may occur; this is most marked in the hip-joint. The prognosis is favourable in these purely typhoid lesions if deformity is prevented; effusion in excess is treated by aspiration or tapping, and washing out; a recurrence may require drainage. If pyococci are present, either alone or together with the typhoid bacilli, suppuration develops and masks the typhoid element. The routine treatment of a suppurating joint is required.

Pneumococcal Arthritis.—In the course of an acute pneumonia the pneumococcus is occasionally disseminated through the body, and is then very likely to attack a joint which has been already damaged, giving rise to a suppurative arthritis with an effusion of thick creamy pus, or sometimes to a milder form of synovitis. Males are more often affected than females, and the upper rather than the lower extremity. Occasionally more than one joint is involved, and, with the exception of the hip, the larger joints are attacked rather than the smaller. There are no special peculiarities in the disease, but since it is merely part of a general infection, the prognosis is not good. When suppuration has occurred. the joint should be tapped or opened and irrigated.

It may also occur primarily and apart from any other obvious pneumococcal lesion. The symptoms are then those of a subacute arthritis with effusion, which apart from active treatment may lead to subsequent limitation of movement.

Gonorrhœal Disease of Joints is always due to infection with the gonococcus, transmitted by the blood from the primary focus of mischief. It is sometimes associated with pyogenic organisms, and then the prognosis is decidedly worse. In the later stages the pus or serum from the joint is sometimes found to be sterile, the gonococci having died after causing the inflammation. Such an occurrence is always suggestive, as sterile pus is rarely found in an acute abscess due to ordinary pyococci. Whilst usually seen in connection with gonorrhœal urethritis in males, it has been known to follow ophthalmia neonatorum, and has been lighted up by passing a full-sized bougie on a patient with gleet. It generally commences after the third week of the gonorrhœal attack, when the discharge is becoming subacute, but may sometimes appear at a much later period. It may involve one or many joints, the knee, ankle, and wrist being most frequently affected, and perhaps on both sides of the body.

Many distinct types of trouble manifest themselves, and they are not unfrequently combined. In one, the synovial membrane is mainly affected, and the effusion is chiefly intra-articular, so that the condition closely resembles an ordinary attack of acute traumatic synovitis, except that it is more severe, more painful, and more persistent. Occasionally a synovial effusion occurs with but little reaction, and then the gonorrhœal origin is likely to be overlooked A more frequent form is that in which the peri-articular structures bear the brunt of the mischief; and there is at first but little effusion *in* the joint, but much around it, the parts even becoming œdematous and reddened; the ligaments are infiltrated and softened, so that displacement readily occurs; surrounding muscles atrophy rapidly; the patient suffers from severe pain and fever, so that he becomes thin and worn. In the worst cases the intra-articular effusion increases, and is sero-purulent, yellowish-green in colour, and contains flakes of lymph; sometimes it becomes frankly purulent. All the forms are very chronic and resistant to treatment, and hence ankylosis, with or without disorganization, is very liable to follow.

The **Treatment** of this condition has been considerably modified of late, and the prognosis improved, by a twofold discovery: (*a*) that the virulence of gonococci is attenuated by a temperature which can not only be tolerated by the tissues, but which improves their activities (p. 159); and (*b*) that in diathermy we possess a means of thus increasing the temperature of the part to which it is applied. The results of the diathermic treatment of this condition have been most satisfactory. Of course, additional measures must be taken to arrest the urethral discharge as soon as possible.

If diathermy is not available, the joint should be kept at rest, and moderate pressure and counter-irritation secured by Scott's

dressing. Bier's treatment by means of an elastic bandage is also useful, and gonococcal vaccines are sometimes most beneficial. Non-specific antitoxin treatment, *e.g.*, the administration of anti-streptococcic or antidiphtheritic serum, either by mouth or rectum, has also proved of value in some cases, probably acting by increasing the general resistance of the body.

Very severe cases must be treated in the same way as a synovitis of pyococcal origin—viz., by incision or tapping and washing out, followed by the introduction of some agent such as glycerine and formalin (2 per cent.); the joint may, if thought desirable, be left open for drainage, but a tube must never be inserted.

Rheumatic Synovitis is met with in the course of acute rheumatism, or as a chronic affection from the commencement. In the former one joint after another is involved; complete resolution usually follows, but there may be some thickening of ligaments and consequent impairment of mobility. If the disease is limited to one joint, absolute disorganization, though without suppuration, may ensue (acute rheumatic arthritis). There can now be little question that this disease is of bacterial origin and due to a diplococcus (Poynton, Paine), or to some form of pyococcal infection of low virulence, as from a chronic pyorrhœa.

The chronic variety is characterized by swelling of the joints, due partly to effusion, partly to thickening of the synovial membrane, and of the capsular and other ligaments. If neglected, it may produce fixity of the joint, due mainly to ligamentous changes, but also resulting from the development of intra-articular adhesions; but there is never any lipping of the cartilages or new formation of bone, as in osteo-arthritis. Not unfrequently other evidences of rheumatism may be present, such as chorea, erythema, etc., whilst rheumatic nodules (*i.e.*, new growths of fibrous tissue beneath the skin, perhaps attaining the size of a walnut, but more often much smaller) may also develop.

The **Treatment** of the acute form is in the first place medical rather than surgical, and general rather than local. The affected joints must be kept at rest in good position, and wrapped in warm cotton-wool, or, perhaps better, soda fomentations may be applied. In the presence of a marked effusion, however, there must be no delay in tapping or opening and washing out the joint, which will be found to be occupied by a greenish, semi-puriform effusion.

In the more chronic forms drugs have but little power, and attention must be directed in the main to the general condition of the patient. The diet must be simple, and butcher's meat, sweets, and rich dishes generally must be avoided. Fish, eggs, and poultry should constitute the chief elements of the protein food. Abundance of plain water must be drunk, either hot or cold as best suits the patient, but *not at meals ;* the fluid should always in these cases be imbibed about an hour before meals. In the early morning before breakfast, it is often wise to add a small dose of Epsom or Glauber's salt to the water, and thus procure a slight purgative effect, thereby

cleansing the intestine. Thus it is possible even at home to secure many of the advantages derived from a visit to a suitable spa, which in persistent cases is very desirable. In addition, acid fruits and vegetables should be avoided, such as rhubarb, tomatoes, and the 'berries' generally. Locally, inunction of an ointment containing some suitable form of iodine, possibly combined with oil of wintergreen (methyl salicylate) is often helpful, but possibly the result is as much due to the massage as to the ointment. Hot-air baths are also good, as also ionic medication with sodium salicylate (p. 313), or diathermy (p. 306). Of course, care must be taken to prevent deformity if practicable, or to correct it, but this is often not an easy matter.

The practitioner must not forget to overhaul the patient thoroughly to ascertain whether or not there is any source of pyococcal infection in the body. Particular attention must be devoted to the teeth and gums; removal of septic roots and decayed teeth has often a marvellous effect in curing so-called rheumatism. Diseased tonsils, chronic suppuration of the nasal passages, chronic urethritis, or leucorrhœa, may also be causative factors, and must be dealt with in an appropriate fashion.

Gouty Arthritis is characterized by certain well-marked features. It often attacks the metatarso-phalangeal articulation of the great toe (podagra), or the metacarpo-phalangeal joint of the thumb (cheiragra). Its onset is usually sudden, and it frequently commences in the middle of the night. The tissues around the joint become swollen, red, shiny, and œdematous, whilst the superficial veins are prominent. The attack is exceedingly painful, and the skin exquisitely tender. These symptoms pass off in the course of a few days, leaving the articulation swollen and sensitive.

Even a single attack results in a slight deposit of bi-urate of soda in acicular crystals in the matrix of the articular cartilage close to the surface; but when the joint has been several times inflamed, the whole thickness of the cartilage may be invaded by this chalky deposit, whilst the ligaments and ends of the bones are also infiltrated. In the smaller joints it may increase to such an extent as to form well-marked swellings, or 'tophi,' similar in character to those so commonly seen in the external ear; the skin sometimes gives way over them, and a chalky discharge results. In some cases the cartilages are eroded, and eburnation of the exposed bone may follow, as in osteo-arthritis. The **treatment** of acute gout consists in fomenting the parts or applying glycerine of belladonna, whilst colchicum, citrate of lithia, and alkaline purgatives are administered. In the more chronic forms iodides may be given, and the diet and drink are carefully regulated. Probably some form of hydro-therapeutic treatment will be required, and if the patient cannot go to a suitable spa much may be done at home by getting him to drink a large glassful of hot water an hour before each meal.

Chronic Synovitis.

This affection follows an acute attack, or may be lighted up by some injury or condition insufficient to determine a more violent form of inflammation. The synovial membrane becomes thick and infiltrated, whilst the effusion is sometimes relatively less than in the acute form, sometimes excessive.

Three varieties have been described: (*a*) **Chronic Serous Synovitis** (Fig. 320) is a condition in which effusion is the most prominent factor. It results from many causes, which throw strain upon the joint, or is sometimes inexplicable. It is not unfrequently associated with some condition such as a loose cartilage, osteo-arthritis, etc., and in its most aggravated form constitutes a condition of *hydrarthrosis* or *hydrops* (p. 733). It is not unfrequently seen affecting the knees after rising from a prolonged stay in bed. The fluid is often clear and limpid and the changes in the structure of the membrane are but slight. The pain is usually not severe, being replaced by a sense of uselessness and weakness. It is interesting to note that, in cases where the effusion is well marked, the bursæ communicating with the joint frequently become distended; they are prevented from participating in the acute forms of inflammation by the fact that the apertures of communication with the interior of the joint are narrow and slit-like, and thus readily become occluded by the swelling of the membrane.

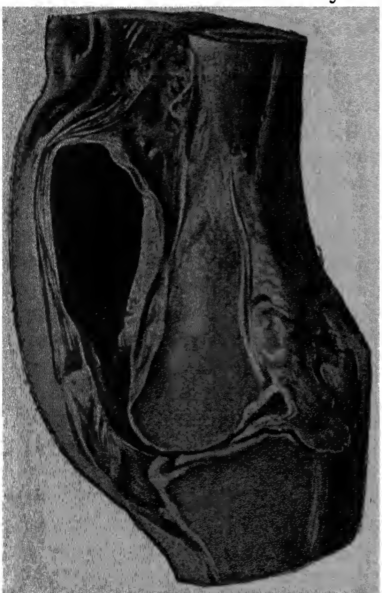


FIG. 320.—CHRONIC SEROUS SYNOVITIS OF KNEE, WITH DISTENSION OF THE SUBCRUREAL POUCH. (FROM COLLEGE OF SURGEONS' MUSEUM.)

(*b*) **Chronic Synovitis with Thickening of the Synovial Membrane** is always a suspicious condition, as it may be a precursor of tuberculous disease, if it lasts, or an outcome of a syphilitic infection. There is but little effusion, and the membrane may even be palpable. Crepitus is sometimes met with in this condition, possibly from a roughening of the articular surfaces on which lymph has been deposited, or between which fibrous adhesions have formed.

(*c*) **Chronic Papillary Synovitis.**—Occasionally the synovial fringes and the villi of the synovial membrane become hypertrophied, giving rise to a condition somewhat similar to that described under osteo-arthritis (p. 747). The overgrown villi usually spring from the

reflections of the synovial membrane close to the bone, and may be loaded with fat, constituting a condition known as 'Lipoma arborescens.' In the knee-joint the fringes may be felt rolling under the fingers, and painful symptoms may be caused by the loose ends being caught and nipped between the bones.

Treatment varies somewhat in the different types, but in all the joint must be kept at rest in a suitable position, and counter-irritation and pressure applied; Scott's dressing and blisters are especially useful in this affection. At a somewhat later stage Bier's hyperæmia may be helpful, or elastic pressure by a Martin's bandage, together with friction with stimulating liniments, or hot-air baths. When effusion is marked and resists these methods of treatment, removal of the fluid by aspiration and subsequent compression may do good; but if the effusion reappears, the best procedure consists in opening the joint, and washing it out with sterile saline solution.

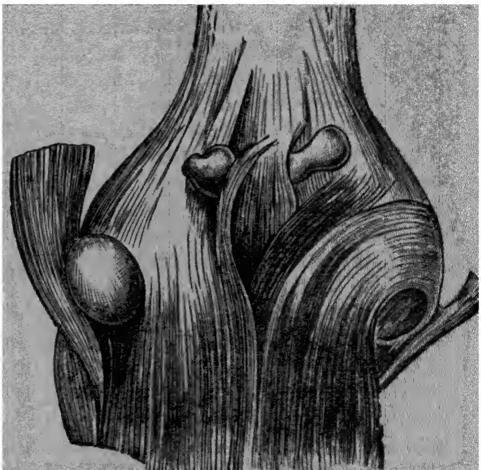


FIG. 321.—BAKER'S CYSTS FROM BACK OF KNEE.

In the chronic fibroid form iodide of potassium may be useful in addition to the above-mentioned methods, but as a rule one has to rely on prolonged massage, radiant - heat baths, ionic medication, or spa treatment.

Should enlarged villi be present and give rise to trouble, the joint should be opened, and if they are limited in their distribution they may be clipped away, or the synovial membrane from which they grow dissected out. When very extensive, so that removal would involve total excision of the synovial membrane and consequent stiffness, it may be wise to wash out and drain, in the hope that they may become fixed, before undertaking complete extirpation of the membrane.

Hydrarthrosis (Hydrops Articuli) is the term applied to any condition of a chronic nature in which the joint is much distended with fluid. It may arise from at least five different affections (*a*) Chronic serous synovitis; (*b*) in osteo-arthritis, a very common cause; (*c*) in Charcot's disease; (*d*) in secondary syphilitic synovitis; and (*e*) occasionally in tuberculous disease. It must be remembered that it is but a symptom, and not a disease *sui generis*, and treatment necessarily varies with the cause.

Baker's Cysts.—This condition, first described by the late Mr. Morrant Baker, consists in a hernial protrusion of the synovial membrane of a joint through an aperture in its fibrous capsule (Fig 321). It is usually due to some chronic affection of the articulation, especially osteo-arthritis or tuberculous disease, whereby the intra-articular pressure is increased, and not uncommonly several such sacs are connected with the same joint. They

vary much in size, contain synovial fluid, and, though at first communicating with the joint cavity, have a tendency to travel away from it, burrowing along muscular and fascial planes, and coming, perhaps, to the surface at a distance from their origin, the aperture of communication with the joint having in some instances been shut off. If causing no troublesome symptoms, there is no necessity to interfere, but if they become inconvenient or painful, it is best to dissect them out, closing where possible by ligature or suture the narrow neck which leads into the joint. Of course, the strictest asepsis must be maintained in all such proceedings, and the causative affection must not be forgotten.

Tuberculous Disease of Joints.

Tuberculous Arthritis (*Syn.:* **Pulpy Degeneration of the Synovial Membrane, White Swelling,** etc.) may commence either in the synovial membrane or in the articular end of the adjacent bone (tuberculous epiphysitis, p. 654); or it may spread to the synovial membrane from the periosteum, as a result of a tuberculous periostitis, or from a neighbouring bursa. In children the disease commences most frequently in the epiphyses, whilst in adults it may start either in membrane or bone with about equal frequency, but considerable variation occurs according to the particular joint affected.

The **Causes** may be summed up as follows: The individual is predisposed to the development of tuberculous disease, often as the result of an inherited tendency; the general health of the patient may also be at fault. Some slight injury, of which but little notice is taken, may lead to the actual deposit of the *B. tuberculosis*, which has been probably lying latent in the bronchial or mesenteric glands, or is present in an active state in the lungs. Severe articular lesions, such as dislocations, are less likely to induce tuberculous disease, partly because their gravity demands efficient treatment, partly because the activity of the reparative process is capable of dealing with the organisms, even if they are brought to the spot.

Pathological History.—The *synovial membrane* becomes thickened, pulpy, and œdematous, and in the early stages is found to be studded with small gelatinous nodules about the size of a pin's head, situated immediately beneath the serous lining; later on, these may amalgamate into caseous masses, which burst and discharge into the joint, leaving ulcerated surfaces. Occasionally these masses are of considerable size; more often they are only small. Finally, the synovial membrane is changed into a so-called pyogenic membrane, consisting of granulation tissue similar to that lining the cavity of a chronic abscess, and more or less closely attached to the surrounding structures, which are transformed into œdematous fibro-cicatricial tissue, whilst the superficial parts undergo fatty or necrotic changes. Fringes of the synovial membrane, swollen and succulent, spread over the margins of the *articular cartilage,* and as they increase in size become adherent to it, just as, according to Billroth's classical description, ivy creeps along a wall. On lifting the edges of these fringes, the underlying cartilage is found hollowed out and eroded. As soon as the whole thickness is destroyed at any one spot, the cancellous tissue at the *end of the bone* becomes invaded by the tuberculous disease, giving rise to caries which is more or less

extensive (Fig. 323), and may be associated with necrosis (p. 655). The granulations spread along under the cartilage, cutting it off from its nutritive supply, and thus large flakes of necrosed cartilage may be shelled off (Fig. 322). New formation of subperiosteal bone is unusual in tuberculous disease, but if pyococcal infection supervene, it may occur. Occasionally the periosteum itself is involved in the tuberculous process, and the disease may then extend some distance from the joint.

The joint itself usually contains but little fluid, being fully occupied by the swollen synovial membrane; but occasionally in the early stages there is much effusion, constituting a condition known as *tuberculous hydrops*, and in it there may be a considerable amount of fibrin, which is moulded by the movements of the joint into the so-called melon-seed bodies. The chief cytological element in the effusion is the lymphocyte.

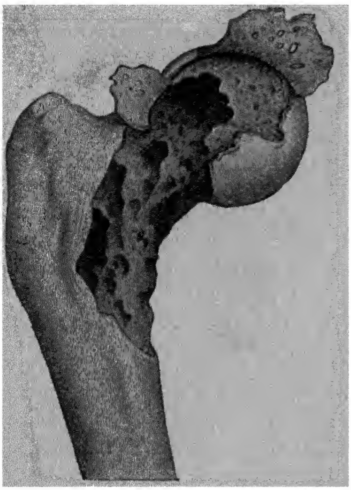


FIG. 322. —TUBERCULOUS DISEASE OF HEAD AND NECK OF THE FEMUR.

The disease evidently started on the under side of the neck, which has been eroded, and spread into the head; the articular cartilage is loose and necrotic fragments of it have been stripped up off the bone.

The peri-synovial tissues are frequently affected in these cases, especially where there is much loose fatty tissue, as around the knee. The parts are infiltrated and gelatinous, and muscles and tendons are incorporated in the swelling and modified similarly in texture. This change constitutes a large element in what is known as the *white swelling* of a joint.

When the disease originates in the bone in adults, the tissue directly contiguous to the articular cartilage is often that primarily attacked; but in children it more frequently starts in connection with the epiphyseal cartilage. The joint is usually infected by extension of the disease through the articular cartilage; but when the synovial membrane extends along the bone beyond the cartilage, as in the hip-joint, it may become involved without any cartilaginous lesion. In the early stages a simple synovial effusion may occur, and should the osseous trouble quiet down and be cured, this may be absorbed, and merely a few adhesions be left. Most commonly the infection is due to the gradual erosion of the cartilage towards its periphery, and the onset of the articular symptoms is then of a chronic type. Sometimes, however, a tuberculous abscess of the bone or surrounding parts bursts into a joint; acute symptoms

supervene, but gradually quiet down, and the usual chronic phenomena subsequently develop.

Clinical History.—The disease usually commences in a most insidious manner. It may be dated back to some injury, but as often as not no such occurrence has been noted. Slight impairment of movement, together with some pain, especially when the limb is jarred or twisted, is perhaps the first sign, causing the patient to limp if one of the lower extremities is involved. This limitation of movement is usually manifested in *all* directions, and this will often assist in diagnosing it from the fixity due to the presence of adhesions in a simple chronic synovitis. The amount of rigidity varies much; in a purely synovial lesion the movements may at first be painless and but little impaired, although the whole region of the joint may be puffy and swollen; when, however, the bone is affected, either primarily or secondarily, the limitation of movement is considerably increased. The position of the limb is that which will give the greatest amount of comfort, and varies in different joints (*q.v.*) and at different stages of the disease. On inspection a superficial joint, like the knee, looks white, smooth, and rounded (constituting the 'white swelling,' or tumor albus of the older textbooks), the swelling being more apparent on account of the wasting of adjacent muscles. On palpation, the part is found to be slightly hotter than that on the opposite side of the body, whilst fluctuation is not readily detected, there being but little fluid in the joint, though the affected tissues are elastic and puffy. In a few cases, where the synovial membrane is widely involved, the affection commences with considerable serous exudation, giving rise to the condition known as *tuberculous hydrops*; after persisting for a while,

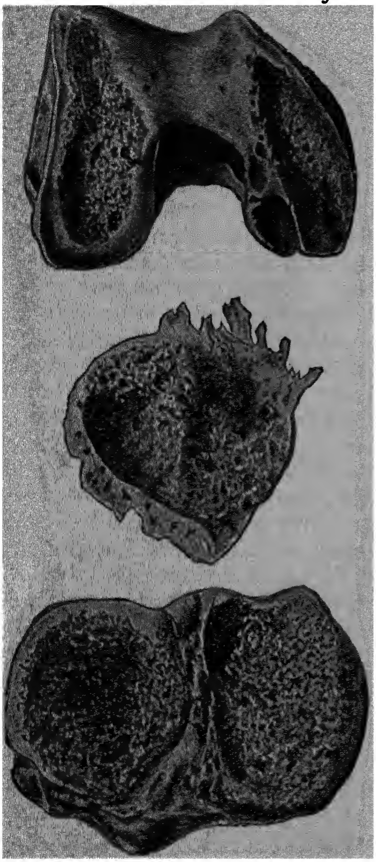


FIG. 323—BONES ENTERING INTO FORMATION OF KNEE-JOINT, WHICH HAS BEEN DISORGANIZED BY TUBERCULOUS DISEASE. (FROM COLLEGE OF SURGEONS' MUSEUM.)

The cartilage is almost entirely destroyed, and the exposed bone is carious and eroded.

the usual manifestations of the disease show themselves. If fibrinous melon-seeds are present, a soft crepitus may be felt on moving the joint. ✓ From time to time exacerbations of pain and increase of swelling occur, which subside after resting for a few days, but leave the joint more and more crippled. Starting pains at night develop when the cartilages are becoming eroded, together with slight fever and malaise. Sooner or later an abscess forms, with increased local and general disturbance; when it bursts or is opened, temporary relief is experienced, but fresh abscesses are liable to form. If pyogenic infection supervenes, the patient develops a hectic temperature; amyloid degeneration of the viscera may follow; the limb becomes more and more deformed; and finally the patient, exhausted partly by the discharge, partly by the pain, and partly by want of sleep, becomes emaciated, and may even die, unless prompt measures are taken for his relief.

Results.—In the early stages with suitable treatment a complete cure may supervene with a movable joint; but later adhesions develop, more or less dense, and with greater or less restriction of movement. Sometimes tuberculous foci are encapsuled in this fibrous tissue, and may cause further pain and trouble from time to time. If the articular cartilage has been destroyed, cure will be associated with new bone formation due to escape of osteoblasts into the granulation tissue from which the adhesions develop; ankylosis must of course result, and any malposition will be thereby fixed. If the condition progresses to suppuration and pyococci are admitted, the disease is aggravated, and unless effective drainage is provided, the bone ends become carious, sinuses form, discharging a varying quantity of pus, and the patient may be exhausted by toxæmia or amyloid disease. Where such dangers are escaped and yet the disease progresses uncured, the limb becomes more and more crippled, and the patient lives more or less an invalid life, with sinuses which dry up or discharge at times, and are a constant source of danger and annoyance. Finally, acute miliary tuberculosis may supervene as a complication at any time, or a tuberculous affection of the lungs, brain, kidney, or other viscera, and may prove fatal.

The **Diagnosis** is by no means easy in all cases, although sometimes it is tolerably obvious. One can never insist too often on the importance of comparing the diseased joint with the healthy whenever possible, observing the differences in contour, colour, temperature, and mobility. The history of the case must be carefully noted, the amount and character of the effusion, and whether or not lymphocytes predominate in a cytological examination; the amount of movement must be ascertained, and whether the limitations are general or particular. Radiography may help, and especially in distinguishing purely osseous conditions—*e.g.*, sarcoma of the end of the bone.

The **Prognosis** is mainly dependent on the stage when the condition is recognized, and on the possibility of securing suitable treatment. School clinics have done much to ensure the early recognition of this condition in children of school age, and the provision of sanatoria, etc., by public authorities is good, as far as

it goes. But there is abundant call for more beds for these cases, and also for some provision to ensure the medical oversight of children under school age. The results of modern treatment are usually good, and, indeed, the complaints of hospital surgeons that they can obtain no material of this type to teach from is most satisfactory. Of course, slum children and those of poor physique generally or with a grave tuberculous inheritance are liable not to benefit as do others. The extremes of life also are unfavourable; babies resist tuberculous invasion badly, whilst patients over fifty years of age have sometimes comparatively little recuperative power.

The **Treatment** of tuberculous joints is conducted along lines similar to those employed for other tuberculous foci.

1. *General* treatment of the sanatorium type (p. 194), or its equivalent, must be instituted as early as possible after a diagnosis is reached, and should be maintained at least until the active stage of the disease has terminated, but for preference until the condition is presumably cured.

2. During this period *local* treatment must be maintained with the twofold end in view, not only of curing the disease, but also of leaving the limb subsequently in as good a functional condition as regards position and movement as possible. In the early stages absolute rest is essential, and must be secured by splints, plaster of Paris, etc.; if there is much pain, and particularly if of the starting type, extension must be applied—just enough to keep the tender ends of the bones from pressing one against the other. Undue weight may cause stretching of the ligaments and subsequent laxity of the joint. Rest must include not only freedom from mobility, but also the absence of pressure; and therefore for all joints of the lower extremity the patient must be put to bed. It is obvious that bed is also indicated for affections of the upper limb in the more active stages. As the condition improves, the patient is allowed to get up, but the same restrictions as regards rest must be maintained to the end of the chapter.

Inasmuch as there is always a likelihood of the development of ankylosis, the position in which the limb is placed is of great importance (see on p. 716). If the position of the limb is already bad when first seen, endeavours to correct it must be instituted at once, and for this purpose weight extension must be relied on. At first it is made in the direction of the displaced limb, and with only just sufficient energy to keep the articular surfaces at rest; gradually the tonic muscular contraction will disappear, and the malposition with it. At other times a little assistance is required in the direction of pressure applied locally to help a displaced bone into position. Tenotomy may occasionally be needed, but any form of apparatus which depends on a screw mechanism is undesirable, as it increases intra-articular tension. The sudden application of force under an anæsthetic is totally inadmissible, as thereby tuberculous material may be disseminated through the system. Scott's dressing (p. 44) is sometimes useful locally for the more superficial joints, and Bier's hyperæmia may occasionally be employed.

3. *Abscesses* should be dealt with sufficiently early and in such a manner as to obviate the need for drainage. To this end they ought never to be left until the skin and subcutaneous tissues are involved; but as soon as a collection can be detected, it should be aspirated, or, if need be, irrigated. For details, see p. 197.

Of course, when the skin is thin and reddened, and the pus subcutaneous, the abscess must be incised and drained in the usual manner, any thin and undermined skin being snipped away.

4. Effective sanatorium treatment and prolonged immobilization in a correct attitude have almost completely destroyed the *operative treatment* of tuberculous joints, and therefore the following section may appear a little out of date; its retention is justified by the fact that the 'ideal' is not always attainable, and surgeons have sometimes to practise the 'best possible.'

A simple *arthrotomy* is sometimes useful. The joint is incised and washed out thoroughly. Disintegrated and loosened cartilages are removed; tuberculous débris is cleared away; the joint cavity is dried out with alcohol and ether, and the exposed surfaces are then 'bipped.' The cavity is closed, and the limb placed in a suitable position and immobilized. Ankylosis will probably result.

Arthrectomy, or erasion, consists in dissecting away all the diseased tissues that can be reached through a free incision. The synovial membrane is cut away; diseased foci of bone are gouged out, and the resulting cavities disinfected by alcohol and 'bipped.' Ankylosis is the usual result. It is obvious that this proceeding is not equally applicable to all joints. Thus, in the hip the opening is usually made from the front, and unless there is great laxity of the capsule and some increase in size of the acetabulum, the back and upper part of the joint cannot be reached. The knee, ankle, and elbow are the most favourable situations for this operation. The chief advantages are that it interferes neither with the immediate length nor with the subsequent growth, whilst there are no extensive sections of healthy bone exposed to infection.

Excision is a more radical measure, but has the disadvantage of removing healthy as well as diseased tissues; whilst the fact that it encroaches on the epiphyseal structures renders it undesirable in children. The chief conditions for which it is now employed in tuberculous disease are: (*a*) For complete disorganization of the joint; (*b*) to prevent ankylosis in certain joints, such as the elbow and temporo-maxillary; (*c*) to determine a rapid and radical cure with synostosis in such a joint as the knee, as soon as it is evident that the natural result of the disease must be an ankylosed limb. Surgical art often produces a more efficient cure than Nature under these circumstances, since all foci can be removed. A natural cure often leaves encapsuled many tuberculous foci, and these may subsequently cause pain and lead to recurrent attacks of inflammation. (*d*) Deformity with or without ankylosis may justify excision.

Amputation is required in cases which, in spite of every care, are steadily going from bad to worse, and where the patient's health and

strength are being sapped by the disease. It is needed not unfrequently in old people, and is indicated in patients where excision has been undertaken and failed, either from the limb becoming subsequently flail-like or useless, or from recurrence owing to incomplete eradication, or from the advent of pyogenic infection. Lastly, if the disease is present in two joints at one time, or in a joint and some other organ, neither of which is improving, total removal of one focus of mischief will often induce a rapidly favourable change in the other.

The choice of operation in any particular case is dependent on a variety of factors which must be taken into consideration: (i.) The *age* of the patient. Typical excisions encroach on the growing ends of bones and render them undesirable in children, for even if growth is not stopped thereby, it may be rendered irregular and cause subsequent deformity. As regards advanced age, the shoulder and knee may be excised satisfactorily later than the elbow, wrist, and ankle. Probably forty to forty-five years would be looked on as the age limit for the latter, but excellent results have been obtained from excising the knee and shoulder at a much later period of life. (ii.) The *general health and vitality* of the individual must be fairly good if either erasion or excision is to be undertaken. In weakly individuals, if conservatism has failed, amputation is usually the better practice. (iii.) The *extent* of the bone mischief. If this is slight, erasion may be undertaken; if more extensive, excision; but if the bone trouble is considerable, so that the removal of the diseased tissue would leave a flail-like, useless limb, then amputation is required. (iv.) Extensive invasion of the soft tissues may also render impracticable all treatment except amputation. (v.) No conservative operations are justifiable in any case where acute or subacute pyococcal suppuration exists, or where pus is retained under pressure, as indicated by discharging sinuses and constitutional reaction. Free incisions to relieve all tension are first required, and subsequently more radical operative treatment may be considered.

Tuberculous Disease of Special Joints.

The **Shoulder-joint** is but rarely affected in children, and not very commonly in adults. The disease usually starts in the head of the humerus, affecting subsequently the synovial membrane, and perhaps also the glenoid cavity. Not unfrequently it results in ankylosis without suppuration (caries sicca). Effusion with the formation of melon-seed bodies is sometimes observed. If abscesses develop, they are likely to point either in front of or behind the deltoid, in the former case extending along the synovial membrane lining the bicipital groove. The ultimate result is usually ankylosis, with perhaps considerable shortening of the arm, or some forward displacement of the upper end of the bone simulating a subcoracoid dislocation. The case is often slow in progress, though persistent, and may be very painful. **Treatment** consists in fixing the arm in the position of rest (p. 716), *i.e.*, abducted to an angle of 40 degrees, and with the hand and forearm directed forwards. When there is much

effusion, the joint may be tapped and washed out by introducing a trocar just external to the coracoid process or below the acromion. For extensive bone trouble (shown radiographically), or if the disease does not improve, excision must be undertaken, and the result is often satisfactory.

In the **Elbow** (Fig. 324) the disease is most common in young adults, commencing usually in the synovial membrane, especally that of the superior radio-ulnar articulation. The swollen synovial membrane bulges on either side of the olecranon and tendon of the biceps, and can often be felt over the head of the radius, and the joint presents the typical appearance of a 'white swelling.' Abscesses form by the side of the olecranon, or may burrow upwards along the ulnar nerve and open on the inner aspect of the arm. **Treatment.**—Prolonged immobilization in the position of rest (p. 716) with suitable hygienic measures should be adopted in the first instance. A poroplastic or internal angular splint reaching from the axilla to the wrist may be sufficient, but plaster of Paris is better. If, in spite of such treatment, the case progresses, the joint should be opened in children, diseased tissues cut or scraped away, and the surfaces 'bipped.' Ankylosis will almost certainly follow, but no attempt to relieve it by excision should be made, or the growth of the limb will be impaired. In young adults arthrectomy or excision may be undertaken with advantage in suitable cases. The former is, perhaps, best effected by means of an H-shaped incision over the olecranon, which is divided at its base and turned up, so as to expose thoroughly the interior of the joint. After removing all diseased tissue, the olecranon is sutured back in place. Excision is often the better practice, especially in adults, as the more extensive removal of bony tissue improves the prospects of gaining a useful movable arm.

FIG 324.—TUBERCULOUS DISEASE OF THE LEFT ELBOW-JOINT.

In the **Wrist** diffuse disease of the synovial membrane and bones is met with, starting most frequently from the former structure. If primarily osseous, it usually commences in the lower end of the radius. It may also extend from a tuberculous affection of the

adjacent tendon sheaths. A characteristic doughy swelling forms over the dorsum, displacing the extensor tendons, whilst the palmar aspect of the wrist is also puffy, and the hand itself is slightly flexed, and the movements of the fingers are impaired by adhesions. Sinuses develop most frequently on the dorsal aspect or by the side of the flexor carpi radialis tendon. Conservative treatment, with the wrist dorsiflexed, may bring about a cure, and every effort should be made to avoid radical operative treatment. Arthrotomy is sometimes useful. The joint is laid open on the ulnar side by an incision which extends between the extensor and flexor carpi ulnaris tendons. Diseased carpal bones and other evidences of the disease are removed. After effecting hæmostasis, the cavity is disinfected with ether, 'bipped,' and packed with gauze, which is removed in a week or ten days; healing by granulation usually proceeds satisfactorily. Sinuses in other positions are merely scraped or excised, and left to heal. Excellent results follow this line of treatment if the hand is kept dorsiflexed, and the fingers and thumb are moved from the first. In elderly people amputation is often the only resource.

Diseases of the **Hip-joint** and of the **Sacro-iliac Articulation** are separately considered (pp. 762 and 771).

The **Knee-joint** is, perhaps, more often affected with tuberculous disease than any other articulation. It appears to start in the synovial membrane or bone with almost equal frequency; if the bones are first attacked, the primary focus is usually situated on the inner aspect of either the femur or the tibia. Sequestra are found in nearly one-half of the cases in which the bone is involved, becoming more frequent as the age advances. The disease runs a typical course, and needs no special comment. When the joint has become disorganized, the tibia is liable to be displaced horizontally backwards, flexed, and externally rotated, and ankylosis in this position is difficult to remedy, even by operation (Fig. 325).

Treatment.—In the more active stages, where the joint is painful and perhaps deformity present, the patient must be kept in bed, and extension applied by means of a suspended Thomas's splint, bent at first to correspond to the degree of flexion. As muscular spasm disappears, the limb and splint can be straightened. If the head of the tibia is displaced backwards, it is advisable to incorporate two special bands of flannel attached to the side-bars of the splint; one passes in front of the limb just above the knee, and the other behind just below. Suitable tightening of these bands tends to lift the head of the tibia into place; of course, effective extension is maintained at the same time. In the later and more chronic stages, immobilization in plaster of Paris or the application of a walking calliper splint will prevent movement, and obviate the harmful effects of pressure from the weight of the body. A patten is placed on the other boot and crutches are used. Abscesses are, of course, dealt with in the usual way.

If in spite of such measures symptoms persist and the case is progressive, a modified arthrectomy may be undertaken in children

through an incision made across the front of the joint from condyle to condyle, dividing either the ligamentum patellæ or perhaps the patella, which is subsequently sutured together. The synovial membrane is dissected away, special attention being directed to the subcrureal pouch and the back of the joint. A thin slice should be removed from the surfaces of both tibia and femur, and if the epiphyseal cartilages are not encroached upon, the growth of the limb is not impaired to any great extent, although it may become irregular and lead to some deformity—*e.g.*, well-marked flexion, or genu recurvatum.

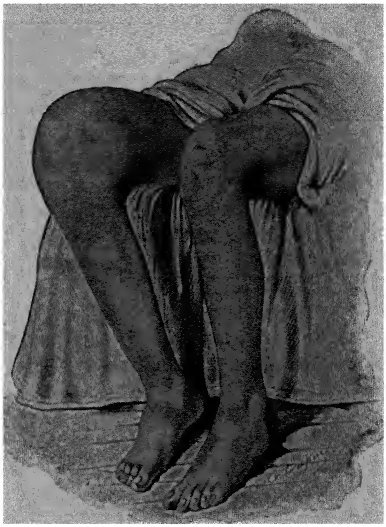


FIG. 325.—TUBERCULOUS DISEASE OF THE KNEE IN AN ADVANCED STATE

The knee is flexed, and backward displacement of the tibia is commencing, the smooth swollen condition of the joint is very characteristic.

In adults, where the bones are not too extensively involved, so that on section broad healthy surfaces can be apposed, excision is a most satisfactory operation, provided, of course, that the synovial disease is also removed. As soon as it becomes evident that the only possible natural cure is by ankylosis—and this evidence would be given by fixation of the patella to the femur, or by severe starting pains at night—excision is both justifiable and advisable. It cuts short the disease, minimizes the risk of general dissemination, and provides a quicker and more radical cure than Nature can possibly effect. Incomplete removal of the disease, either in the synovial membrane or bone, may determine recurrence; if this cannot be dealt with effectively, amputation may be required, and then a long

posterior flap is the only healthy tissue available for covering the bone. Under other circumstances the ordinary supracondyloid amputation can be adopted.

The Ankle-joint.—Tuberculous disease of this joint usually commences in the synovial membrane rather than in the bone. The whole region becomes occupied by a pulpy swelling, which first pushes forwards the extensor tendons and bulges in front of the malleoli and subsequently appears on either side of the tendo Achillis. Pain is often slight, and the movements of the ankle may be but little impaired; the calf muscles are usually wasted. In the later stages, when the bones are involved, the pain increases, and the foot is maintained in a position of slight plantar-flexion, so as to bring the narrower portion of the upper surface of the astragalus into the tibio-fibular mortice. Flexion and extension of the foot are usually limited or lost, but with care the lateral movements (inversion and eversion) which occur at the mid-tarsal and sub-astragaloid joints can be undertaken without pain. If the disease is primarily osseous, localized painful areas occur over the lower ends of the tibia or fibula, or over the astragalus, and the osseous lesions can be demonstrated by radiography. In either type of case, abscess formation is very liable to follow, and may become extensive, owing to the implication of tendon sheaths. **Treatment.**—In the early stages prolonged rest and immobilization in plaster of Paris or a Thomas's splint are required. Operative treatment is never very satisfactory. Arthrectomy can be undertaken, but removal of the astragalus and of all available synovial membrane is probably a better course to adopt. When, however, the astragalus is involved, it is often difficult to eradicate the disease, which has probably spread to the articulations and bones beneath it, and amputation may then be required. Where the disease also involves the tibia and fibula, a supramalleolar amputation of the foot will probably be necessary.

For diseases of the **Bones and Joints of the Foot,** see p. 652.

Syphilitic Diseases of Joints.

Although syphilitic disease of joints is rare in proportion to the prevalence of syphilis, yet several varieties have been differentiated and recognised. (1) In the later stage of the secondary period a *chronic* form of *synovitis* occurs, evidenced by passive effusion into the joint, with or without pain. and usually persisting for some time. Any joint may be attacked in this way, perhaps the knee most commonly, and the affection is often symmetrical in its distribution. The effusion may be only slight, but is frequently very considerable (hydrarthrosis), and a marked feature in the condition consists in the rapid variations in the amount of swelling, even from day to day. In some few cases this affection resists all treatment, and leads to ultimate disorganization. (2) *Gummatous* inflammation of the *peri-synovial* fibrous tissue, which may or may not extend to the adjacent bone, is met with in the tertiary period. It either appears as a localized hard nodule, resembling in measure a fibrous tumour, and

then causing but little trouble beyond a sense of painful weakness in the articulation; or it is more diffuse in its distribution, leading to a moderate effusion, and later on to much thickening and infiltration of the capsular and other ligaments, and resulting in considerable impairment of its movements from cicatricial contraction. Some of these gummatous nodules may break down and ulcerate. (3) A diffuse *gummatous infiltration of the synovial membrane* itself is also seen, usually in children. It closely simulates a tuberculous synovitis, from which it is often impossible to distinguish it locally, except by the rapid onset, the absence of pain, the greater amount of effusion, and the symmetry which is sometimes present. It may occur apart from other evidences of congenital syphilis, but the Wassermann reaction will be helpful. (4) A *chondro-arthritis*, described originally by Virchow, is the syphilitic analogue of osteo-arthritis. It commences by fibrillation of the matrix of the cartilage, and proliferation of the cells. The cartilage softens, and becomes eroded by friction of the articular surfaces. The bone thus exposed is worn away, and curiously 'pitted' or excavated. It is distinguished from osteo-arthritis by the facts that there is usually but little or no pain; that the eburnation of the exposed bone is less extensive, and therefore crepitus is but little marked; whilst the typical osteophytic outgrowths and 'lipping' of the joint margins are absent. The eroded areas, moreover, do not correspond with the sites of intra-articular pressure, and are more rounded and punched out, and not arranged in linear grooves, as in the latter disease. It is not uncommonly associated with a gummatous thickening of the synovial membrane, and, indeed, the hollows or pits above mentioned may be filled with caseous material derived from degeneration of this tissue.

The **Treatment** in the early manifestation consists in the administration of mercury or salvarsan, and the judicious application of pressure with or without immobilization, according to the requirements of the case and the joint affected. In the tertiary forms iodide of potassium in gradually increasing doses has a rapidly beneficial action, which confirms the diagnosis; it may be occasionally combined with a small amount of mercury, either given internally or applied locally if any ulcerative lesion exists. In the most pronounced cases, where the pain is severe and disorganization of the joint has occurred, excision may be necessary, and the results are often very satisfactory.

Osteo-Arthritis and Chronic Rheumatoid Arthritis.

Under these titles is included a considerable group of chronic diseases of joints characterized by marked changes in ligaments, syonvial membrane, and articular ends of the bones, and leading on, if the condition persist, to permanent crippling and deformity. This may occasionally involve only one joint, but more frequently it is polyarticular, the hands and feet being specially attacked, and even the spine does not escape. The diseases are extremely common, and yet

times these osteophytes attain considerable dimensions, and by interlocking may lead to ankylosis of the joint.

The bone exposed by the destruction of the articular cartilage is altered as the result of the movements of the joint. The chronic irritation causes it to become hard, sclerosed, and polished like ivory (*eburnation*). This usually occurs in certain definite directions; in hinge-joints the surfaces become grooved longitudinally, whereas in ball-and-socket joints like the hip the head is eburnated in a circular manner. This condensed tissue does not extend very deeply, and immediately beneath it the bone is of a more open texture than usual and filled with fatty medulla. In spite of the sclerosis the articular end of the bone is being constantly worn away, and this may progress to such an extent as to lead to actual shortening of the limb.

Clinical History.—Three chief types of this disease may be described:

1. The *chronic monarticular variety* is that most frequently seen by surgeons, and is constantly brought about by injury. Pain and creaking of the joint on movement are the early symptoms. There may be very little swelling, unless effusion is present, but pain, especially at night, is most troublesome, being usually increased on changes of weather, particularly if rain is threatening. The pain and stiffness are most marked after keeping the parts at rest, and diminish when the limb is used. As the disease progresses, the movements become more and more impaired, and the creaking may be transformed into a true bony crepitus; the ends of the bones are felt to be enlarged and lipped, and deformity soon becomes obvious. Exacerbations in the symptoms occur from time to time, resulting in increased crippling. Finally, the limb may become absolutely useless, partly from the pain and partly from the limitation of movement produced by the osteophytes. Wasting of the adjacent muscles is also a marked feature.

This variety is usually seen in elderly people, and may supervene quickly after an accident, such as fracture or bruising of the cervix femoris, and then the destructive phenomena may progress at a rapid rate. When it appears in younger people, the osseous lesions are much less evident.

2. The *chronic polyarticular variety* (*osteo-arthritis*) arises independently of traumatism, and is most commonly seen in females of middle life. It may commence in one joint, and that often the hip or the knee, and spread to others, or it may appear in many joints simultaneously. Most frequently one or more of the phalangeal articulations is the starting-point, particularly the terminal ones, or the carpo-metacarpal joint of the thumb, and then it may be the result of an injury. The joints become stiff and swollen, are tender, and in the milder cases small nodular bony outgrowths develop at the bases of the phalanges, which are known as Heberden's nodosities. Gradually some degree of flexion occurs, accompanied by increasing stiffness and ulnar adduction of the fingers, which

Pathological Anatomy.—The disease may commence either in the synovial membrane or in the articular cartilage, but perhaps more frequently in the former, particularly in the acute and subacute varieties. In the early stages the synovial membrane becomes vascular and thickened, but there is often little effusion, so that the affection has been termed 'arthritis sicca.' The villi may, however, proliferate, so that the surface becomes shaggy or villous in appearance, and then the effusion may be more marked. Sometimes the villi reach such dimensions that they can be felt through the skin, rolling under the finger; they are red, vascular, and succulent during life, but after removal and preservation in spirit they look shrunken and insignificant. At times there is a considerable development of fat in these villi, constituting the condition known as *lipoma arborescens*, and often associated with an added element of gout. Occasionally cartilaginous nodules are found in the villi, and these may subsequently undergo ossification; if detached, they may constitute one form of loose body in a joint (p. 756).

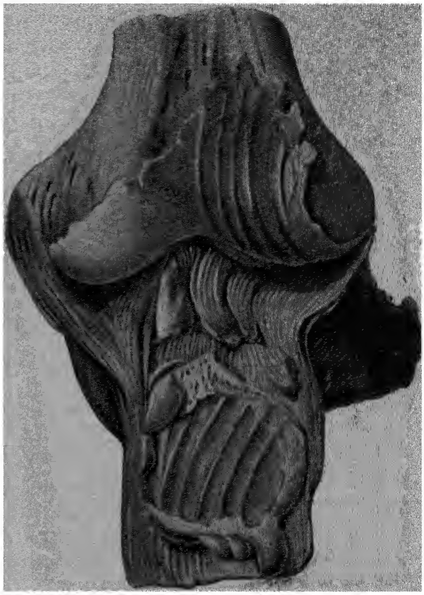


FIG. 327.—LATE STAGE OF OSTEO-ARTHRITIS OF KNEE, SHOWING DESTRUCTION AND LIPPING OF THE ARTICULAR CARTILAGE, AND EBURNATION OF THE EXPOSED BONE IN LONGITUDINAL GROOVES. (FROM COLLEGE OF SURGEONS' MUSEUM.)

The changes in the cartilage, whether primary or secondary, consist in a breaking up of the matrix into fibres, the so-called 'fibrillation,' so that the surface becomes rough like the pile on carpet or velvet (Fig. 326). Meanwhile the cartilage cells are arranged in longitudinal rows between the fibrillæ and proliferate within their capsules, which become distended and burst into the joint. The cartilage thus softened is readily worn away by the movements of the articulation, and the surface of the bone is exposed. Concurrently with this destruction, hyperplasia is taking place at the margins of the articular cartilage, resulting in the production of irregular overgrowths (*ecchondroses*), which have been likened to the gutterings of a candle. In them ossification occurs secondarily, and when such overgrowths have been produced more or less evenly around the joint margin, a characteristic lipping of the edge of the articular surface results (Fig. 327). Some-

times these osteophytes attain considerable dimensions, and by interlocking may lead to ankylosis of the joint.

The bone exposed by the destruction of the articular cartilage is altered as the result of the movements of the joint. The chronic irritation causes it to become hard, sclerosed, and polished like ivory (*eburnation*). This usually occurs in certain definite directions; in hinge-joints the surfaces become grooved longitudinally, whereas in ball-and-socket joints like the hip the head is eburnated in a circular manner. This condensed tissue does not extend very deeply, and immediately beneath it the bone is of a more open texture than usual and filled with fatty medulla. In spite of the sclerosis the articular end of the bone is being constantly worn away, and this may progress to such an extent as to lead to actual shortening of the limb.

Clinical History.—Three chief types of this disease may be described:

1. The *chronic monarticular variety* is that most frequently seen by surgeons, and is constantly brought about by injury. Pain and creaking of the joint on movement are the early symptoms. There may be very little swelling, unless effusion is present, but pain, especially at night, is most troublesome, being usually increased on changes of weather, particularly if rain is threatening. The pain and stiffness are most marked after keeping the parts at rest, and diminish when the limb is used. As the disease progresses, the movements become more and more impaired, and the creaking may be transformed into a true bony crepitus; the ends of the bones are felt to be enlarged and lipped, and deformity soon becomes obvious. Exacerbations in the symptoms occur from time to time, resulting in increased crippling. Finally, the limb may become absolutely useless, partly from the pain and partly from the limitation of movement produced by the osteophytes. Wasting of the adjacent muscles is also a marked feature.

This variety is usually seen in elderly people, and may supervene quickly after an accident, such as fracture or bruising of the cervix femoris, and then the destructive phenomena may progress at a rapid rate. When it appears in younger people, the osseous lesions are much less evident.

2. The *chronic polyarticular variety* (*osteo-arthritis*) arises independently of traumatism, and is most commonly seen in females of middle life. It may commence in one joint, and that often the hip or the knee, and spread to others, or it may appear in many joints simultaneously. Most frequently one or more of the phalangeal articulations is the starting-point, particularly the terminal ones, or the carpo-metacarpal joint of the thumb, and then it may be the result of an injury. The joints become stiff and swollen, are tender, and in the milder cases small nodular bony outgrowths develop at the bases of the phalanges, which are known as Heberden's nodosities. Gradually some degree of flexion occurs, accompanied by increasing stiffness and ulnar adduction of the fingers, which

renders the hands very helpless (Fig. 328). The trouble gradually spreads to other joints, and although there are often remissions, yet the condition progresses steadily until the patient may be entirely crippled thereby. Well-marked overgrowth of bone and eburnation of the articular ends are characteristic features of this type. Deformity is due to bony outgrowths rather than to muscular contracture. Sometimes there is considerable effusion, accompanied by overgrowth of the synovial villi, but this is unusual.

3. The *acute polyarticular variety* (*rheumatoid arthritis*) does not often come to the surgeon for treatment, at any rate in the early stages. It usually attacks young or comparatively young people, and females rather than males, frequently following some infective trouble, such as influenza, scarlatina, tonsillitis, etc. It is often ushered in by a distinct febrile attack, with persistent increase in the rate of the heart-beat; trophic and vasomotor phenomena are often co-existent, such as patches of pigmentation, clammy cold

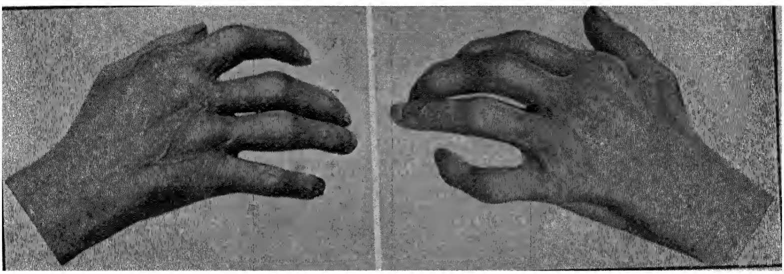


FIG. 328.—HANDS OF PATIENT WITH CHRONIC POLYARTICULAR OSTEO-ARTHRITIS, SHOWING NODULAR CONDITION OF THE JOINTS AND MARKED FLEXION AND ULNAR ADDUCTION.

hands, and rapid muscular atrophy. The smaller joints of the hands and feet are mainly affected, and that more or less symmetrically, although the terminal interphalangeal articulations often escape. The capsules are distended with a certain amount of effusion, causing the joints to look spindle-shaped, and at first, though there is much periarticular thickening and often a good deal of fibrositis, there is but little osseous mischief. In not a few cases a very characteristic deformity in the shape of ulnar adduction of all the fingers occurs. Gradually the trouble spreads to other and larger joints, and osseous manifestations appear, but deformity is due to muscular contraction; the progress is slow, and may be to a large extent arrested by treatment. Neighbouring lymphatic glands may be enlarged in the early stages.

The peculiarities of this affection, as it involves children, have been emphasized by Dr. Still. Girls are more often attacked than boys; many joints are implicated, and neighbouring lymphatic glands are enlarged. The cartilage is but little altered, and bony

outgrowths are absent. The spleen is also enlarged, and there may be pericardial and pleural adhesions.

It is important to note that gouty and rheumatic troubles may be associated with osteo-arthritis; the rheumatic affections may precede, the gouty usually follow. Fibrositis (p. 462) is often an accompaniment of either type.

The **Diagnosis** of these affections *per se* is not often difficult in a well-marked case, the crepitus, pain, and enlargement of the ends of the bones, together with the slight amnont of effusion, constituting a tolerably characteristic picture. Radiography may show the typical lipping of the articular ends, and the thinning of the bony substance beneath the cartilage. It is, however, not easy to differentiate one variety from the other in the early stages. From simple *chronic synovitis* it may be known by the history and smaller amount of effusion, and by the pain and rigidity being frequently more marked after rest, and diminishing after the joint has been actively used. There is more difficulty in distinguishing the form associated with increased effusion and enlargement of the synovial villi; careful examination may, however, enable the surgeon to make out these villi moving to and fro in the joint under his hand, whilst possibly the ends of the bone may be lipped. For diagnosis from *chronic rheumatism* and *Charcot's disease*, see pp. 730 and 754.

The **Prognosis** is usually unfavourable. The fact that many joints are affected is an indication that there is a considerable constitutional element in the causation of the disease, and, although it may be temporarily combated with success, still, sooner or later, the patient is almost certain to be crippled by it. The affection of only one joint often points to a traumatic origin, and the outlook is brighter.

Treatment.—For this troublesome complaint there is, unfortunately, little that can be effected in the way of cure, although much can be done to alleviate. Locally, the articulations should be protected from cold and injury by being swathed in flannel, whilst stimulating embrocations or sedative applications may be beneficially employed. It is not advisable to maintain the joints absolutely at rest, otherwise their mobility is likely to become seriously limited at an unnecessarily early date. Moreover, it is often found that the more a joint is moved, the easier and less painful do the movements become, and hence regular massage is desirable. Hydrotherapy, electrotherapy, and treatment by the local application of heat (p. 306) have a large field of usefulness in this affection. As to general treatment, the individual is warned against exposing himself to cold and damp, and since the disease is often considered to be due to perverted or diminished nervous activity, all possible sources of irritation and worry should be removed. At the same time the nutrition must be improved, and plenty of good food, cod-liver oil, etc., administered. A large number of different drugs have been tried for this complaint, but none of them are very satisfactory. Perhaps the best are guaiacol carbonate, or iodide of sodium combined with some alkaline purgative and hepatic stimulant, such

as sulphate of soda. Natural mineral waters and baths are often beneficial, those of Bath and Buxton in this country being most frequently recommended, though the sulphur waters of Harrogate and Strathpeffer are also beneficial. Arsenic is sometimes useful.

All possible sources of infection are explored, and if any are found suitable treatment is adopted. In particular, attention is given to the teeth (pyorrhœa), and to the intestinal canal (stasis). Any joint with marked effusion may be tapped with a view to prepare an autogenous vaccine.

The effect of *non-specific vaccines* is being carefully explored, and it seems probable that considerable value is to be attached to this procedure. The idea is that thereby the development of antibodies, and with it the general resistance of the body to germs, is increased (p. 23). The vaccine most often used is one containing the *B. typhosus*, and the paratyphoid A and B bacilli. The dosage needs to be carefully regulated, but no good seems to follow unless a definite febrile reaction is produced.

Occasionally operative treatment in the shape of *excision* may be undertaken in this complaint, but only when the disease is limited to one joint, and when it has progressed to such a stage as seriously to cripple the patient's usefulness, as in the knee-joint, elbow, or the shoulder, or when the act of mastication is impaired, owing to an affection of the temporo-maxillary articulation. In suitable cases excellent results are obtained. The possibility of excising the osteophytic growths has also been mooted, and in suitable cases it may be attempted.

The *hip-joint* is not uncommonly the seat of osteo-arthritis in old people, and it always causes a considerable amount of pain, usually referred to the sciatic or anterior crural areas of distribution, or perhaps to both; it is noticed especially on flexion of the limb, rendering sitting difficult and walking uncomfortable, whilst the movements become more and more curtailed. The limb early appears to be shortened, but this is in reality due to its adduction and a compensatory tilting up of the pelvis on the affected side so as to maintain the parallelism of the legs. The adductor muscles will usually be found tense and contracted, and abduction of the limbs is markedly diminished, even at a time when flexion is scarcely limited at all. At a later date true shortening (Fig. 329) follows, with, perhaps, increased deformity, owing to erosion and 'mushrooming' of the head and excavation of the acetabular cavity, which is enlarged upwards by the absorption of its posterior lip. Well-marked lipping of the acetabular margin and head of the femur occurs, and thereby much impairment of movement is produced and easily elicited crepitus. The trochanter is unduly prominent in most cases where true shortening is present, and this is an important diagnostic sign, especially when a fracture of the neck is suspected in a patient who has fallen on the hip.

Treatment in these patients is important, inasmuch as serious crippling is caused by the disease In cases which have progressed beyond the stage when hydrotherapy, vaccines, or physiotherapy

can be expected to help, surgical assistance is often sought. If radiography can demonstrate that there is no grave deformation of the head, it is sometimes desirable to correct malposition and increase the range of available movement by manipulation under an anæsthetic. Apart from this, the formation of a firm, painless ankylosis is the only measure that can be expected to give much relief, and to secure this an arthrodesis may be undertaken. The articular surfaces are effectively denuded, and the head well pushed home into the acetabulum; the great trochanter may be detached, and re-attached at a lower level so as to give better purchase to

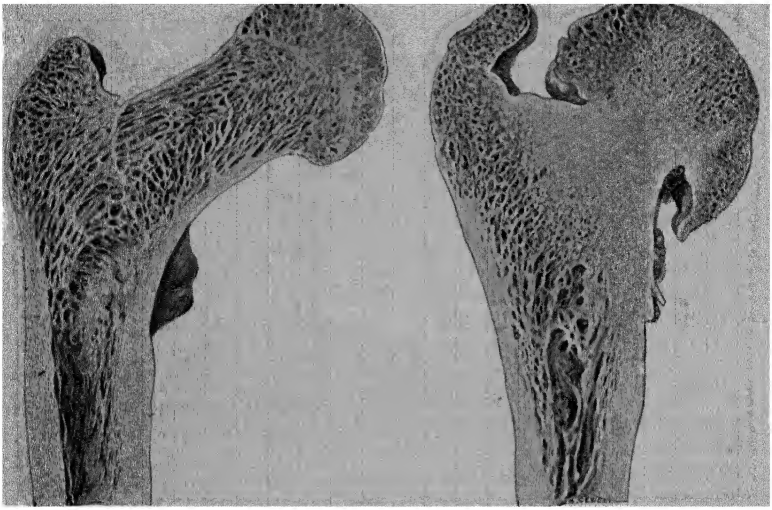


FIG. 329.—OSTEO-ARTHRITIS OF THE HIP.

A normal femur in section has been placed alongside of the affected one for comparison; the absorption of the neck and the relative elevation of the trochanter are obvious, as also the distortion of the head of the bone.

the abductor muscles inserted into it, and thereby hinder the likelihood of an increasing adduction. Reports of cases indicate that this procedure is really of value.

When the *temporo-maxillary joint* is affected, the condyle of the jaw becomes larger than usual and somewhat flattened; the eminentia articularis is partially absorbed and the glenoid cavity increased in size, so that the condyle is liable to slip forwards, owing to the action of the external pterygoid muscles. If only one joint is affected, the bone is carried towards the sound side, but when both are involved the chin becomes prominent owing to a forward displacement of the whole bone. Pain and crepitus are experienced on opening the mouth, rendering mastication difficult and even impracticable. If ordinary treatment fails to give relief, the affected condyle of the jaw should be excised

Neuropathic Arthritis (*Syn.*: **Charcot's Disease**).

This disease, bearing the name of the late Professor Charcot, is a peculiar affection of joints met within the course of locomotor ataxy. It is slightly more common in women than men, and is almost always an early manifestation, occurring usually between the lightning-like pains and the onset of the ataxic symptoms. The most typical form is lighted up by some slight injury—*e.g.*, a strain or sprain—and is characterized by a rapid painless distension of the joint with a light-

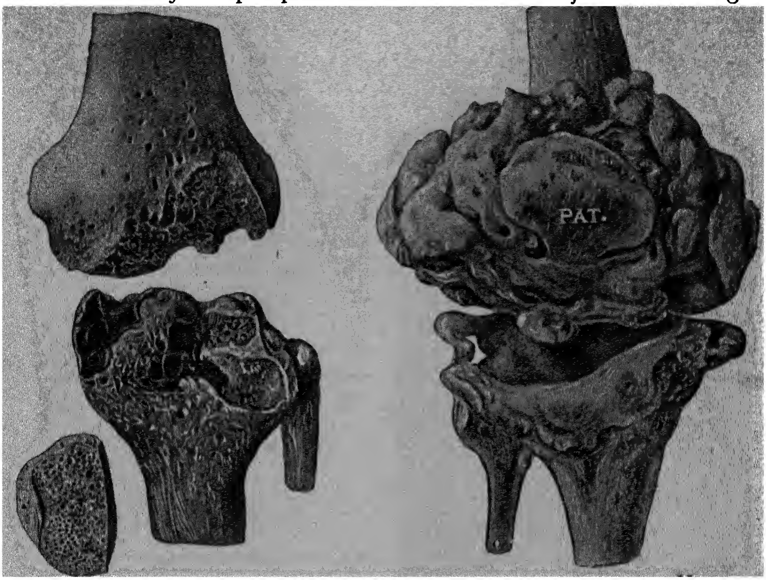


FIG. 330.—ATROPHIC VARIETY OF CHARCOT'S DISEASE OF KNEE-JOINT. (FROM COLLEGE OF SURGEONS' MUSEUM.)

The bones are cleanly eroded, and no new formation is present. The patella is reduced to a mere shell, one-eighth of an inch thick.

FIG. 331.—HYPERTROPHIC VARIETY OF CHARCOT'S DISEASE OF KNEE-JOINT. (FROM COLLEGE OF SURGEONS' MUSEUM.)

The patella (PAT.) can be seen poised on the top of a mass of new bone formed by the welding together of a number of smaller portions formed in the perisynovial tissues.

coloured serum, which may also extend into the communicating bursæ; there is some amount of effusion into the surrounding cellular tissue, although without œdema. This distension may be so rapid that abnormal mobility or even dislocation may occur at the end of a few hours. The joints most frequently affected are the knee, hip, and shoulder, occasionally more than one articulation is involved. The course of the case varies; in some few instances the fluid is gradually absorbed, and the joint returns to its normal size and shape, although somewhat weakened. Sometimes the attacks of distension

recur, and after each the joint becomes more and more crippled. Two chief types of the affection are described: (1) In the *atrophic* variety, the more common, the bones become eroded to a considerable extent, the ligaments stretched, and a weak, flail-like articulation remains, in which the ends of the bones are atrophied and displaced (Figs. 330 and 332). (2) In the *hypertrophic* form new osseous formations occur here and there under the synovial membrane, especially in cases where there is much distension, so that on compression of the swelling between the hands a sensation is produced similar to that imparted by grasping a bag of bones. After a time these osseous masses become welded together, giving rise to large overgrowths, which lead subsequently to fixation of the joint (Fig. 331). The disease sometimes runs a more chronic course, and then closely resembles osteo-arthritis, since there is but little effusion, whilst the ends of the bones become eroded, and osteophytes, perhaps of great size, form around the edges of the cartilages, leading to defective mobility and crepitus.

Fig 332.—Charcot's Disease of Left Knee.

The joint is distended with fluid, and displacement of the tibia is commencing.

The **Diagnosis** of Charcot's disease from *osteo-arthritis* is, as a rule, readily made if one remembers the following points: Charcot's disease is usually characterized by a rapid onset, limitation to one joint, considerable effusion, absence of articular pain atrophy of the ends of the bones, and a tendency to the production of a weak, flail-like joint, whilst the early general signs of tabes are also observed, especially the lightning pains and the Argyll-Robertson pupil. Osteo-arthritis, on the other hand, comes on slowly, often affects many joints, has but little effusion, is very painful, and is attended with marginal overgrowth or lipping of the cartilages (R.S., Fig. 30). In the more chronic cases the distinguishing features are much less evident.

The **Treatment** of Charcot's disease consists in keeping the limb at rest on a splint and applying elastic pressure. The effusion, when considerable, may be removed by an aspirator, but is very likely to re-collect. Ionic medication with salts of iodine may be of use. In the later stages, where the joint is entirely disorganized, some form of fixed apparatus, such as a carefully moulded splint, may be applied to render the limb more useful, and it is remarkable how well a

patient can get on in this way with a badly-affected joint. In the worst cases, however, amputation may be required.

The same type of articular lesion occurs in *Syringomyelia*, a disease which consists in a gliomatous development in the spinal cord, and usually in the cervico-dorsal region. It is characterized by loss of the senses of pain, and of heat or cold, but tactile and muscular sensibility persists Atrophy of various muscles of the hand or forearm also occurs, whilst trophic lesions—*e.g.*, whitlow, perforating ulcer, etc.—are common. Joint troubles are observed in at least one-third of the cases, mainly in the upper extremity, tabes generally affecting the lower. Either atrophic or hypertrophic phenomena are developed, and the course is identical with that of Charcot's disease, except that suppuration is a little more likely to follow, owing to the frequent presence of infected sores.

Somewhat similar in nature to Charcot's disease is the chronic arthritis met with in many conditions where the nervous supply to a limb is impaired as a result of central or peripheral disease of the nervous system. Thus, it may follow spinal bifida, hemi- or para-plegia of cerebral or spinal origin, or may be secondary to a peripheral neuritis, due to either injury, syphilis, gout, diabetes, leprosy, etc. The terminal articulations of fingers or toes are those most often affected (acro-arthritis), although larger joints may be involved. They become swollen and painful, and after a time ankylosis ensues.

Hæmophilic Disease of Joints.

In hæmophilia (p. 338) any injury to a joint may lead to a copious effusion of blood into the articular cavity, which becomes suddenly swollen and distended. The blood remains fluid for a time, but at length coagulates, and the joint then becomes tense and firm, and is often hot and tender. Total recovery may ensue, but if the condition recurs, as is so frequently the case, the effects on the articular surfaces are curious: the cartilages usually retain their normal colour, but become thin, worn, and rough, especially at the points of greatest pressure; fibrillar degeneration of the matrix may occur, and in some cases the cartilage has been found totally absent, being replaced by fibrous tissue. Ecchondroses subsequently developing into bone are formed at the margins of the joint surfaces, the changes thus produced being somewhat akin to those of osteo-arthritis. The ligaments and synovial membranes are slightly thickened, and usually of a russet-brown colour. Adhesions are often present, causing considerable impairment of mobility. The **Treatment** consists in keeping the part at rest, and applying ice in the early stages; whilst, later on, friction, massage, and pressure may be employed. The surgeon must never attempt to aspirate the joint, even with a fine needle.

Loose Bodies in Joints.

Several varieties of loose body are met with in joints, which may be described as follows: (1) The so-called 'melon-seed bodies' consist of fibrin derived from altered blood-clot, or more frequently from a fibrinous exudation in cases of very chronic tuberculous disease. At first irregular in shape and laminated in texture, they are generally transformed into round or flattened pellets or elongated masses by the movements of the articulation. Bursæ and tendon sheaths

are much more frequently affected than joints. The number present is usually considerable, whilst there is also some glairy effusion, causing distension and a certain amount of creaking. In one case the knee-joint was occupied by a number of rounded, yellowish-white, translucent foreign bodies, several of which were nearly as large as walnuts; thev were probably of hæmorrhagic origin. (2) Portions of articular or intra-articular cartilage may be broken or are separated off as a result of direct mechanical violence. They usually consist of a smooth rounded mass of articular cartilage enclosing a central bony nucleus (Fig. 333). The most common situation for this to occur is the lower end of the femur; when the knee is fully bent, the articular surface is exposed to direct violence. If not broken off immediately, the injured fragment may be separated without pus formation; it is sometimes found attached to the under side of the femur by a pedicle of fibrous tissue, which allows of only limited mobility. Radiography may demonstrate the foreign body and the cavity in the lower end of the femur from which it has been derived. (3) They sometimes develop from cartilaginous nodules in the synovial fringes or villi, which either become pedunculated, then occasionally wearing a bed for themselves in the articular surface, or may be totally detached. Such structures are usually lobulated and irregular in shape, and consist of calcified cartilage or bone, whilst a certain amount of normal cartilage is also present (Fig. 334). This condition may result from osteo-arthritis, but sometimes the cartilaginous cells from which they are derived have persisted as a 'fœtal residue.'

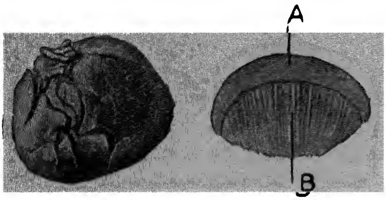


FIG. 333.—FOREIGN BODY IN JOINT PROBABLY DERIVED FROM A PORTION OF ARTICULAR CARTILAGE. (FROM COLLEGE OF SURGEONS' MUSEUM.)

A, Cartilage; B, bone.

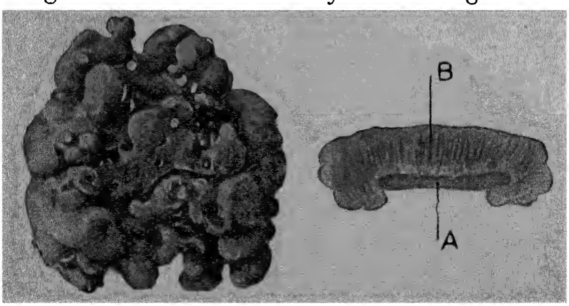


FIG 334.—LOOSE CARTILAGE IN JOINT, PROBABLY DEVELOPED IN A FRINGE OF SYNOVIAL MEMBRANE (FROM COLLEGE OF SURGEONS' MUSEUM)

A, Cartilage, B, bone.

(4) Ecchondroses may be broken off in cases of osteo-arthritis, or even portions of the articular cartilage showing villous changes.

Although cut off from all vascular supply, the growth of some of these loose bodies is said to continue, owing to the highly nutritious fluid which bathes their surfaces.

The **Symptoms** caused by this condition are produced by the loose body being occasionally caught between the articular surfaces, leading to a temporary locking of the joint, and severe pain, owing to the stretching of the ligaments. The fixation is but momentary, since the foreign body is readily displaced, but an attack of subacute synovitis follows. When this has happened several times, the ligaments are likely to become relaxed, and the joint somewhat loose and distended. It may then be possible to feel the foreign body, and to shift its position, but frequently the surgeon is unable to detect the intruder, as it slips away into the interior of the joint owing to its ready mobility. From this point of view, the term 'Gelenkmaus' (joint mouse), as applied to this affection, is most happy. The knee and elbow joints are those most frequently affected.

The **Diagnosis** between a loose body and a torn and *movable semilunar cartilage* in the knee-joint is not always easy, since in both conditions painful locking of the joint occurs. The fixation, however, is but momentary in the case of a loose body, but may persist until reduced in the latter, whilst a localized spot of tenderness may be detected corresponding to the site of the injury to the interarticular cartilage. Moreover, the history of the case is very different, since the dislocation of a semilunar cartilage is always primarily referred to some twist or sprain of the joint, whereas with a loose body no such traumatic influence need be present. It is always possible to detect a loose body by radiography, if there is any osseous tissue in it, and therefore all cases of chronic synovitis where the cause is at all in doubt should be radiographed.

The **Treatment** consists in the removal of the foreign body by an open operation (p. 717). In the knee-joint a vertical incision is made about 2 inches in length, extending a little above and below the line of the articulation. It should be placed about 1 inch from the patella, on whichever side the loose cartilage presents most frequently, but preferably on the outer. If possible, the foreign body should be fixed by the finger in one of the lateral pouches of the joint before making the incision. The capsule and synovial membrane are opened, the loose body removed, and the cavity carefully closed.

Neuromimetic and Neuralgic Joints.

In nervous individuals of either sex it is not uncommon to observe a persistence of joint disability with or without pain long after the causative trouble has passed away. In a few cases this is definitely due to malingering; but more frequently it results from want of will-power and effort on the part of the patient, possibly because he

has been warned in too forcible terms of the dangers of movement. A patient of this type needs help and encouragement; he has walked perhaps for some time with the foot everted, and is unwilling to put his weight fairly on hip or knee. Re-education in the correct method of walking is necessary, and his muscles must be carefully trained; much can be done by suggestion and will-power.

Where numbers of wounded men have been brought together, a persistent disability is often purely **neuromimetic** in origin; one or two of the number limp as a result of their wounds; others follow their example because it seems to be the proper thing for a wounded man to do. Injudicious, though kindly, sympathy may maintain this condition. A most careful examination must be made before such a diagnosis is reached. The muscles governing the joint must be tested, and their electrical reactions noted. If the patient's attention can be diverted, movement may sometimes be obtained without pain. In some cases examination under an anæsthetic is most desirable; possibly a little peripheral stimulus during the administration, in the stage when the patient has lost consciousness, but retains his muscular activity, may be helpful.

In a few cases a true **neuralgic** condition of a joint occurs, in which disease is simulated, and yet no actual lesion is present. On careful examination the pain is found to be superficial, not increased by jarring the articular surfaces together, and often not strictly confined to the joint. The movements are apparently limited, but if the attention of the individual is diverted or anæsthesia induced, they are found to be perfectly free. There are no signs of effusion into the cavity, and no starting pains at night. Occasionally a similar condition is met with in men, where there is no suspicion of hysteria.

The *treatment* is constitutional and local. The former is directed towards improving the general health, and correcting any error in the uterine functions. The latter is best accomplished by the use of cold douches and electricity, although counter-irritation in the shape of blisters, or even the actual cautery, applied over the joint, has an excellent moral effect.

Ankylosis.

By ankylosis is meant a condition of immobility, partial or complete, of a joint, resulting from some preceding inflammation of the articular structures.

The term **false** ankylosis is sometimes applied to a condition resulting from extra-articular lesions. It may be either fibrous or osseous, and is due to cicatricial contraction of the skin, shortening or fibrosis of muscles, or even to the development of bony tissue within them (*myositis ossificans*). A common and troublesome form of false ankylosis after fractures or gunshot wounds is due to

the fixation of muscles to the underlying bone. Thus, in many cases the quadriceps is fixed to the front of the femur by such dense fibrous adhesions that movement of the knee is quite impossible, although the patella may be freely mobile from side to side. Similarly the triceps may be fixed to the back of the humerus and prevent movement of the elbow.

True ankylosis always involves the articular structures, and is either fibrous or bony.

Fibrous or incomplete ankylosis results (*a*) from thickening and contraction of the ligaments, such as often occurs after gonorrhœal or rheumatic affections; (*b*) from the formation of cord- or band-like adhesions within the joint, after acute synovitis or fractures involving the articular surface; (*c*) from erosion of the cartilage and

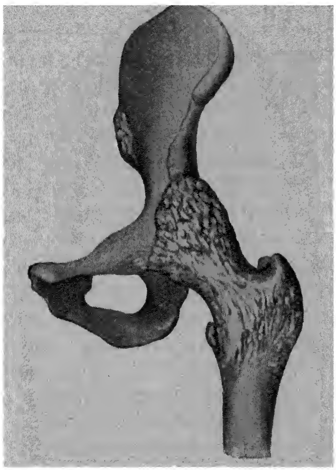


FIG. 335.—ANKYLOSIS OF HIP-JOINT IN GOOD POSITION AFTER EARLY HIP DISEASE. (KING'S COLLEGE HOSPITAL MUSEUM)

exposure of the bone, as in acute or tuberculous arthritis; granulations sprout up on each side, and by their union lead to dense fibroid adhesions between the articular surfaces. Some amount of movement is possible in most of these cases.

Complete or osseous ankylosis (synostosis) arises from the union of either the whole or part of the opposing surfaces left by the destruction of the cartilage, the bond of union, at first fibro-cicatricial, being subsequently ossified (Fig. 335); it may also be due to the interlocking and fusion of osteophytes, formed at the margin of the bone in osteo-arthritis or Charcot's disease.

The position in which ankylosis occurs and the *effects* thus produced differ according to the joint affected. (See also pp. 716 and 298).

In the *shoulder* there is usually but little displacement, and the existence of immobility is of less importance than elsewhere, owing to the free movements of the scapula and clavicle. The deltoid muscle is generally much atrophied. The *elbow-joint* is very commonly ankylosed on account of its exposed position, and the frequency of fracture-dislocations in its neighbourhood. The formation of callus filling up the olecranon and coronoid fossæ, and the adhesions likely to form within the joint in these cases, readily explain its frequency. The most favourable position for ankylosis is when the arm is flexed to a little more than a right angle, with the hand slightly supinated so that the patient can see into the palm. By this means access to the mouth is possible, and he can use his hand for feeding purposes. Occasionally, however, the patient's work is such as can best be undertaken by a straight arm. The *wrist* is most commonly fixed as a result of gonorrhœal or rheumatic synovitis. In the *hip-joint* (Fig. 335) much depends upon the treatment as to whether the ankylosis takes place in a good or bad position. Slight flexion of the thigh (about 35 degrees) is probably the best position to ensure comfort both in sitting and standing, combined with moderate abduction. In neglected cases the thigh may be in a position of adduction and internal rotation, crossing in front of the other leg. Occasionally a *scissor-like deformity* has resulted from inflammation of both hip-joints, one leg lying in front of the other; progression is accomplished with difficulty, the body twisting at each step, and crutches are often needed. In ankylosis of the *knee-joint* an absolutely straight position is not quite so serviceable as when some slight degree of flexion (15° or 20°) is present. Unless care is taken in treating the causative affection, ankylosis is only too likely to be associated with deformity. The knee becomes much bent, and the tibia is displaced backwards on the femur, whilst external rotation and even lateral displacement of the tibia [redacted] are likely to supervene if the patient is allowed to lie with his leg on its outer aspect. In the *ankle-joint* considerable trouble may arise from immobility, unless the foot is at right angles to the leg.

The **Treatment** of ankylosis must vary considerably according to its cause. In the simple forms of *fibrous* ankylosis, due to the presence of adhesions of no density, much may be done by manipulation, massage, and exercises. Some adhesions may be dealt with by forcible movements under an anæsthetic, the surgeon ever keeping in mind that the bones involved may be atrophic and easily broken (p. 720). Others are better treated more gradually, efforts being directed to lengthen and loosen the adhesions rather than to break them. Remedial exercises may be useful in this direction.

An exception to all vigorous treatment of this type, as also to some of the operative methods suggested below, is made in the case of ankylosis following tuberculous disease. The surgeon can never be certain that infective foci are not encapsuled in the

fibrous tissue, and active treatment might once again light up active disease.

It is useless to attempt the rupture or division by open operation of dense adhesions, as they are certain to re-form. These cases, as also certain non-tuberculous forms of osseous ankylosis, perhaps due to pyæmia or trauma, are best treated by the operation of **arthroplasty,** elaborated by J. B. Murphy. The procedure is based on the recognized fact that one of the most frequent causes of the non-union of fractures is the interposition of fibrous, fatty or muscular tissues between the fragments. If, then, the articular ends of an ankylosed joint can be separated, and a suitable flap of tissue interposed, the free movement of the joint should be restored, granting that the muscles which control the joint are operative. For this purpose free or pedunculated fascial flaps stitched over the bone ends are now chiefly employed, and give the best results. It is impossible here to enter into lengthy details of the procedure;* it must suffice to state that the joint affected must be freely exposed; the articular ends are set free, and a gap made between them, which must be maintained until healing has occurred; shaping or rounding the bone ends may be desirable, but is not essential; the fascial graft is placed so as to cover completely the articular end of one or both bones involved, and stitched *in situ* ; and then the wound is carefully closed. It is immobilized for a week or ten days, and then movements are commenced. The result in many cases is most gratifying, but, of course, all infective trouble must have ceased before the operation is undertaken, and absolute asepsis is essential if the flap is to live.

Excision of joints for ankylosis is still occasionally required, especially in the *elbow*, but takes on the form of an arthroplasty in the majority of cases. It should never be considered when a labouring man has a strong useful arm, even if stiff. In the *knee* osseous ankylosis with deformity will frequently require the removal of a wedge-shaped fragment (cuneiform osteotomy) in order to overcome the deformity; where, however, the ankylosis is fibrous, arthroplasty will usually be practicable.

At the *hip-joint* ankylosis in a bad position is most commonly due to tuberculous disease, and, as already stated, arthroplasty is then not desirable. Most frequently the thigh is flexed on the pelvis and possibly adducted, the result being a most ungainly method of progression. In the majority of such cases it is unwise to attempt division of the cervix femoris (Adam's operation); it is too near the diseased area. Subtrochanteric osteotomy of the femur is the operation of choice; a small incision is made just below the trochanter, and through this an osteotome is introduced and the bone divided. To put the limb in a good position, tenotomy of the adductors is usually required, and this is easily effected subcutaneously close to the pubes. The after-treatment must be sufficiently long to ensure sound and solid union of the bone, as the adductors are powerful,

* For further details see E. Hey Groves, *Brit. Journ. of Surgery*, October, 1923.

and can readily lead to displacement when the callus is soft. In non-tuberculous ankylosis of the hip the joint is best exposed by a large U-shaped incision with its base upwards, and the trochanter well within the U. This flap is raised, including the deep fascia. The base of the trochanter is chiselled across, the joint is exposed, and the head of the femur separated from the acetabulum and shaped up so as to move freely in the deepened and smooth socket. A flap of fascia is then carefully wrapped round the head of the femur and stitched in position. Divided ligaments are re-united; the trochanter is nailed back in position, and the wound closed. The limb is placed in a position of abduction with weight extension, and passive movements are commenced in ten days.

Hip-Joint Disease.

Although the term 'hip-joint disease' is usually applied to a tuberculous arthritis, it is not the only affection involving this articulation, as rheumatic, gonorrhœal, or pyæmic affections are not very uncommon. Acute arthritis is also met with secondary to an acute infective osteomyelitis of the upper end of the femur, and is evidenced by all the ordinary signs of that affection, separation and necrosis of the upper epiphysis being a frequent result. Osteo-arthritis is frequently seen (p. 751), whilst Charcot's disease may also occur.

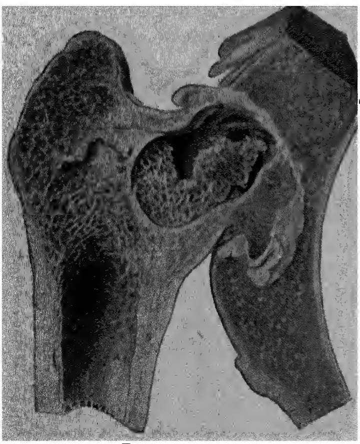


FIG. 336.—TUBERCULOUS HEAD AND NECK OF FEMUR WITH SEQUESTRUM LYING IN AN ABSCESS CAVITY. (COLLEGE OF SURGEONS' MUSEUM.)

The condition was of old standing, as evidenced by the absorption of the head, the destruction of the joint cavity, and the chronic changes in the bone which surrounds the sequestral cavity.

Tuberculous Disease of the Hip (*Syn.*: **Morbus Coxæ, Tuberculous Coxitis, Coxalgia**) differs in no respect from the same disease as it affects other joints, and hence no detailed notice of the pathological anatomy is required. Suffice it to say that it may originate in the synovial membrane or bone, more frequently in the latter, and then commencing either beneath the articular cartilage or on the under side of the neck distal to the epiphyseal cartilage (Fig. 336). Very rarely the disease becomes circumscribed in the neck of the bone, forming a chronic abscess, the diagnosis of which is exceedingly difficult. More usually the disease spreads from the under side of the neck, and involves the synovial membrane, which passes into a state of pulpy degeneration. The substance of the epiphysis is

invaded, and caries of the head is thereby produced, together with necrosis or ulceration of the cartilage (Fig. 322). The acetabulum undergoes similar changes; from the contact and backward pressure of the diseased head the posterior acetabular margin is absorbed and the cavity extended, whilst at the same time a new rim of bone forms beneath the adjacent periosteum at a slightly higher level, thus giving rise to what is known as a 'travelling acetabulum' (Fig. 337). In this way the socket is increased both in size and depth, travelling

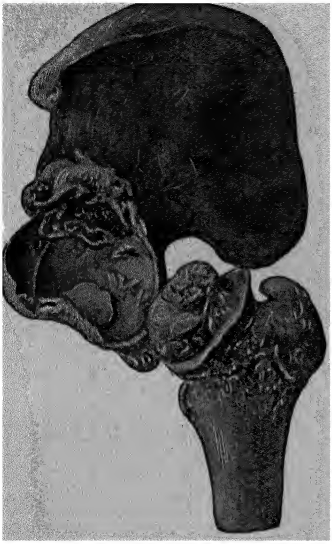


FIG. 337.—FEMUR AND ACETABULUM IN HIP DISEASE. (KING'S COLLEGE HOSPITAL MUSEUM.)

The epiphysis of the caput femoris has been practically destroyed, and the acetabulum is enlarged by absorption of its posterior margin and displaced upwards (*travelling acetabulum*). The rami of the ischium and pubes have been removed.

FIG. 338.—EARLY STAGE OF HIP DISEASE (LEFT SIDE) IN A CHILD. (FROM A PHOTOGRAPH.)

The black line is drawn from one anterior superior spine to the other, and shows not only the amount of abduction present, but also the tilting down of the pelvis on the affected side.

backwards and upwards with the head of the bone towards the dorsum ilii. Other factors assisting in the displacement of the head of the bone are: the tonic action of the muscles, keeping the limb in a position of flexion, adduction and inversion, thereby causing a considerable portion of the head to project out of the acetabulum; and the early softening and destruction of the posterior ligaments, which are much thinner than those in front of the joint. Occasionally a mass of protuberant granulations sprouts up from the centre of the cavity, and may also assist in this process. Should the acetabulum

be perforated, a tuberculous abscess is likely to form within the pelvis. The adjacent pelvic bones may either become thickened by the deposit of osteophytes, or carious; if a pyogenic infection is superadded, necrosis may supervene.

Clinical History.—The patient, usually a child, is observed to limp, and may complain of pain either in the hip or more often on the inner side of the knee, the latter being due to the fact that both joints are supplied by the same nerves—viz., the anterior crural, sciatic, and obturator trunks. There may be some history of injury, but not necessarily. On examining the limb in the *early stage*, it is usually found to be *apparently lengthened* (Fig. 338), whilst the thigh is slightly wasted. The nates are flattened, and the gluteal fold lost, conditions partly due to atrophy of the muscles, partly to the flexion

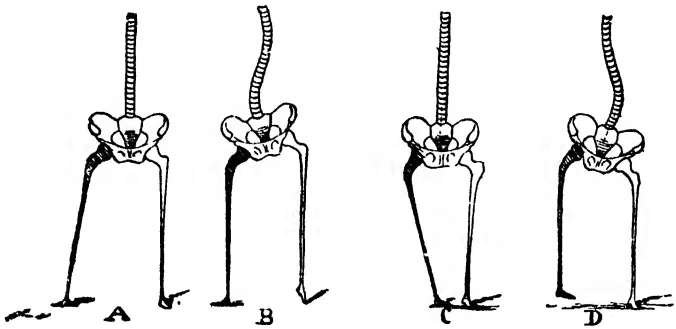


FIG. 339.—DIAGRAM TO ILLUSTRATE THE POSITIONS ASSUMED BY THE LIMB IN THE EARLY AND LATE STAGES OF HIP DISEASE.

A represents the position of abduction taken by the right limb in the early stage of hip disease, and B, Nature's method of masking this by tilting the pelvis down on the affected side, while the other leg is adducted; the effect of this on the spine, in causing a lateral deflection, is also indicated. C shows the same thing in the later stage, when adduction is present, and the pelvis is tilted upwards on the affected side, thus producing apparent shortening (D).

of the limb. The joint is more or less rigid, and pain is produced on attempting to move it, or on jarring the leg, as by striking the heel or trochanter. Direct pressure over the neck of the femur—*i.e.*, over a spot just below and internal to the anterior superior spine—causes pain in the earlier stages of active disease. The position assumed in this early stage is one of slight and increasing flexion, abduction, and eversion (Fig. 339, A), the reason for this being that thereby the ligaments, and especially the ilio-femoral, are most relaxed, and the capacity of the joint is at its greatest. The latter fact has been demonstrated in the healthy cadaver by inserting the nozzle of a syringe into the joint through the acetabulum, and forcibly injecting fluid, when this position is at once assumed. The flexion and abduction, however, are not always evident, since the flexion is

masked by lordosis of the spine (Figs. 340 and 341), and the abduction by the pelvis being tilted down on the affected side, producing thereby apparent lengthening of the diseased limb and lateral curvature of the spine, with its lumbar convexity towards the affected side (Fig. 339, A and B). The sound leg being brought into a position of adduction, the parallelism of the limbs is maintained. The flexion can be demonstrated by any method which obliterates the lumbar curve of the spine, as by fully bending up the sound limb on the abdomen, the affected thigh rising at once from the bed and

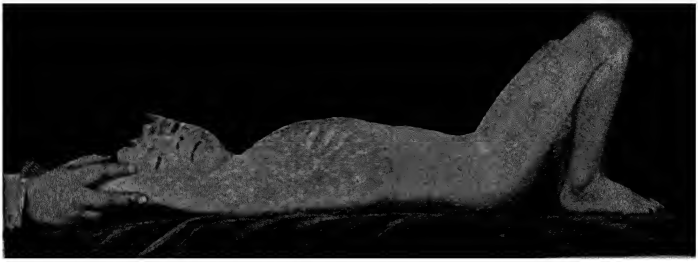
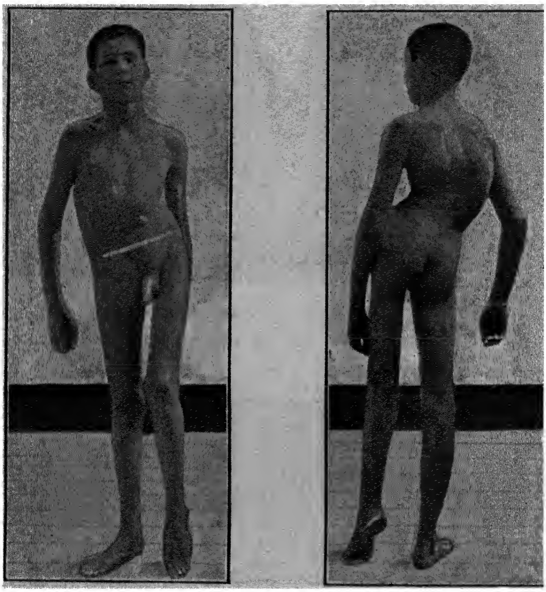


FIG 340. —HIP DISEASE, WITH THE BACK FLAT ON THE COUCH, AND THE LEG FLEXED TO A CONSIDERABLE DEGREE.

FIG 341.—ON PRESSING DOWN THE DISEASED LIMB, THE SPINE BECOMES ARCHED (LORDOSIS) IN THE LUMBAR REGION, SO THAT THE HAND COULD BE READILY PASSED BELOW IT. THE EVERSION OF THE LIMB IS VERY EVIDENT.

forming an angle which indicates the amount of flexion (Fig. 340). The abduction is demonstrated by laying a rod across the two anterior superior spines, and placing another at right angles to its centre. This will not correspond with the line of the body or of the limb, but makes an angle with it. The eversion cannot be masked. The rigidity is easily demonstrable in that all movements of the hip-joint are greatly limited; thus if an attempt is made to bend the affected thigh on the abdomen, the corresponding side of the pelvis is raised with it from the bed.

As the disease progresses, and the bones become more extensively affected, the pain increases, with nocturnal startings, whilst abscesses form, and a certain amount of fever and constitutional disturbance is caused thereby. The position of the limb also changes; for although the flexion is maintained, and even increased, adduction and inversion are now associated with it. The pelvis is tilted up on the affected side (Fig. 339, C and D), causing *apparent shortening*, lateral curvature with a lumbar convexity to the sound side, and abduction of the healthy limb. No satisfactory cause for this position can be



A B

FIG. 342.—POSITION OF THE LEFT LEG IN THE LATER STAGES OF HIP DISEASE

In A a white line has been drawn between the two anterior superior spines to indicate the tilting of the pelvis upwards on the affected side necessitated by the adduction of the limb. Some amount of flexion was present, but this was not marked. In B the secondary curves of the spine are well seen.

given, but it is usually attributed to the yielding of the posterior and outer part of the capsule, together with infiltration and weakening of the small external rotator muscles, allowing the adductors and internal rotators unopposed play.

When an abscess has formed, the most usual situation for it to point is a little in front of and internal to the great trochanter, close to the insertion of the tensor fasciæ femoris. It may reach that spot either from an opening in the anterior part of the capsule, coming thus to the surface along the line of least resistance, or it may

burrow from the posterior portion of the capsule along the rotator muscles and superior gluteal nerve. Less frequently abscesses pass directly backwards to open in the gluteal region, or forwards along the pubo-femoral ligament, pointing on the inner side of the femoral vessels below Poupart's ligament As a rare complication, the tuberculous process may extend to the bursa under the psoas tendon, which sometimes communicates with the joint, leading to the formation of an abscess in the upper part of Scarpa's triangle, and occasionally to a typical psoas abscess from extension upwards. An intrapelvic abscess following perforation or disease of the acetabulum may either burrow upwards, and come to the surface above Poupart's ligament, or may gravitate downwards, and burst in the ischio-rectal fossa.

The final stage of the disease is one of *real shortening* (Fig. 342), due to erosion of the head of the bone and its displacement backwards upon the dorsum ilii. The position assumed is one of increased flexion, adduction, and inversion; whilst if suppurating sinuses persist hectic fever and amyloid changes in the viscera are likely to follow.

At any stage cure by ankylosis may be obtained; but unless the abnormal position has been corrected by extension, deformity is almost certain to be present, whilst interference with growth may increase the shortening (R.S., Fig. 21).

The **Diagnosis** of hip disease appears to be a matter of considerable difficulty to some, if we may argue from the mistakes which commonly occur. *Examination* of all cases of hip disease must always be thorough and methodical, if such errors are to be avoided. The child should be examined stripped, and made to walk, if possible, so that the character of the limp may be observed. Apparent lengthening or shortening of the leg, tilting of the pelvis, and the condition of the gluteal fold should reveal much as to the position of the limb. The child is next placed on a flat couch with both legs extended, and the curvature of the lumbar spine noted. Thomas's manœuvre (Figs. 340 and 341) to obliterate the lordosis will reveal the amount of flexion of the hip. The actual length of the limb, Bryant's measurement, and the relation of the top of the trochanter to Nélaton's line are next all noted. The degree of fixity or freedom of the limb is carefully investigated as regards each movement—flexion, extension, abduction, adduction, and internal or external rotation; and here a caution is needed—viz., that conditions vary much according to whether the child has previously been walking or resting. A few weeks' rest will eliminate much of the muscular spasm in early cases, especially as regards flexion and extension; sharp abduction may then elicit muscular spasm in the adductors. In the later stages, as cure is advancing, spasm is more and more difficult to detect, but the following plan suggested by Sir Henry Gauvain is valuable:

If the femur on the affected side be grasped firmly in the region of the condyles, it will be found that the head of the bone may be gently rotated within the acetabulum, either inward or outward, through a varying but often

considerable angle. At the point where this movement is checked a further slight sharp rotation is instantly followed, if the disease is still active, by spasmodic muscular contraction, not confined to muscles about the joint, but extending to the abdomen and visible in the abdominal muscles, or still more easily demonstrated if the palm of the hand is placed on the abdomen between the iliac spines. Quite a gentle and painless, but sharp, rotary movement is sufficient to provoke this reflex spasm of the abdominal muscles. Failure to elicit it does not necessarily imply that there is no active disease, but its presence certainly indicates an active lesion.

From disease of the *knee* or *opposite hip* mistakes can only arise as the result of carelessness and want of observation. The diagnosis from *sacro-iliac disease* is given at p. 772. *Spinal mischief* ought never to be a cause of error, even if a psoas abscess points at one of the situations ordinarily favoured by abscesses due to hip disease. The presence of spinal deformity and the ability to perform the test movement for hip disease should readily enable the surgeon to make a correct diagnosis, but it must not be forgotten that the two conditions often co-exist. If the limb can be put into what is known as the tailor's position—that is, flexion of the knee to a right angle, with marked abduction and eversion of the thigh—one may be practically certain that hip disease is not present.

It is difficult to distinguish an *encapsuled abscess in the neck of the femur* from true hip disease. A constant deep boring pain is complained of, which is increased by pressure over the neck, or by jarring the trochanter; but if the limb is manipulated gently, it can be proved that the movements of the joint are not really impaired.

Radiography should always be employed in all cases of suspected hip disease, and by its means such conditions as coxa vara (p. 498) and pseudo-coxalgia (p. 771) are readily recognized. It is, however, sometimes difficult to be certain as to the nature of the inflammatory attack following a *slight injury*. The patient is treated as for the graver affection, and if it gets well in a week or two, probably it is not tuberculous.

The **Prognosis** of hip disease is by no means unfavourable if the condition is properly treated. Of course, the patient is liable to develop acute tuberculosis or tuberculous disease elsewhere; or, if abscesses are allowed to become septic, serious complications—such as pyæmia, toxæmia, hectic and amyloid disease—may ensue. Apart from these, however, no serious consequences affecting life need be feared, although the usefulness of the limb may be seriously crippled from shortening or ankylosis, especially if the latter occurs in a faulty position.

The **Treatment** of hip disease follows along the usual lines for dealing with tuberculous lesions. The *general* treatment of the patient should be of the sanatorium type, or as closely adapted to it as possible (p. 194).

Locally, prolonged rest and extension are the essentials in all stages, although modifications must be introduced in the various degrees. Any deformity present must be gradually corrected, and

the possibility of its development or increase during treatment must not be forgotten. The means of rest and extension now generally employed is the Thomas's splint (p. 541). Strips of adhesive plaster taken well up above the knee are employed for extension purposes, together with a weight and pulley, or attached to the cross-bar. The limb should always be slung, either from a pole at the end of the bed or from a Balkan beam. Gradually the muscles relax, and the limb returns to the normal position. If there is at first marked deformity, the leg has extension applied in that direction, but before long, if the extension is effective, it will be possible to place the limb in a good position. The relations of the limb to the pelvis must be carefully watched throughout treatment, or an unsuspected adduction may develop. In some cases it may be desirable to employ Bradford's abduction splint in place of the ordinary Thomas, with which it corresponds as regards the possibility and method of extension, but it has an additional pelvic attachment which tilts the affected limb into an abducted position.

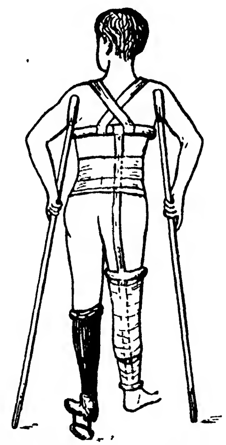


FIG. 343. — THOMAS'S HIP SPLINT APPLIED.

In the simpler cases, where these appliances are not available or desirable, all that is requisite may be secured by weight extension to the affected limb, and the application of a Liston's splint to the sound side; or the child may be fixed down by sandbags or a Bryant's splint applied. The extension strapping must always be carried well above the knee, so as not to damage the ligaments of that joint, and only enough weight must be used to prevent painful starting of the limb. If the amount of flexion is slight, the limb may be allowed to lie on the bed in a horizontal posture; this will probably induce some compensatory lordosis, but as the spasm decreases, the curvature of the spine disappears.

When the more urgent symptoms have disappeared, as indicated by the absence of pain on removal of the weight, a Thomas's hip splint is applied, so as to enable the patient to get about (Fig. 343). This consists of a flat bar of malleable iron, about an inch and a half wide, extending from the lower part of the axilla nearly to the ankle; it is shaped so as to fit the varying curves of the body, and cross-pieces embrace the trunk at the level of the nipples, as also the thigh and the calf; it is firmly bandaged to the body and limb. A patten is placed under the boot of the sound leg, and the patient allowed to get about on crutches. This apparatus should be worn for at least six months after all signs of active disease have disappeared.

Abscesses are dealt with by aspiration or tapping, in accordance

with the general rules already given (pp. 197 and 739). It should seldom be necessary to do more in the operative line, but occasionally when a case, in spite of rest and suitable hygienic measures, is not progressing satisfactorily, as shown by the persistence of pain, especially of starting pains at night, or by a raised temperature, or by the incidence of a local swelling, suggesting the formation of an abscess, and especially if radiography indicates the existence of a localized lesion, it is justifiable to cut down on the joint from the front and remove all the caseous débris, degenerated synovial membrane, and diseased cartilage and bone that can be reached without too great a disturbance of the parts. The joint is dried with absolute alcohol or ether, and sterilized iodoform or ' bipp ' is then rubbed in and the wound closed. In some cases a temporary dislocation of the head is even justifiable, and then the acetabulum can be more effectively treated. The epiphyseal cartilage of the upper end of the femur should always be saved, if possible, so as not to interfere with the growth of the bone. Sometimes the mischief is so extensive as to necessitate the removal of the whole head. The limb is put up in a Thomas's knee splint in a position of abduction, or in a Bradford's abduction frame, with some degree of extension to counteract or prevent deformity, and subsequently in plaster of Paris.

In the *later stages*, when the case has been neglected and sinuses have formed in the gluteal region or behind the trochanter, *excision* by the *posterior* method is sometimes required; this is usually an easy matter, since the head is probably eroded and displaced. The sinuses should, if possible, be included in the incision, but under any circumstances must be opened up and scraped. When the acetabulum is extensively implicated, the disease can only be satisfactorily dealt with by removing the head of the bone, and the posterior method affords the best means of subsequent drainage; of course, this presumes that the general condition of the patient has not been seriously undermined, and that there is a good prospect of gaining a useful limb. Otherwise *amputation* through the hip-joint is required, especially when the mischief has extended into the pelvis, or when, after excision, a weak, flail-like limb results or osteomyelitis supervenes. It is also needed when after excision sinuses persist and lead down into the acetabular cavity, from which there is a plentiful secretion of pus, and over the entrance to which the upper end of the femur is drawn, thereby obstructing the escape of the discharge, and rendering dressing both difficult and painful. The operation often gives most excellent results, the patient's condition rapidly improving. Removal by the anterior racquet method is perhaps the most convenient, in that the division and ligature of the vessels can sometimes be accomplished through a separate incision, or at any rate at a spot where drainage is most complete, and infection least likely to occur. Happily, amputation for hip disease, and even the posterior type of excision, are at the present time only of historical interest.

Pseudo-coxalgia or **Coxa Plana** (*Syn.:* Osteo-chondritis Deformans, Legg's, Perthes' or Calvé's Disease, Quiet Hip Disease, etc.*).—The multiplicity of names associated with this disease is as ever a measure of the ignorance as to its nature which still exists. It occurs most frequently in boys between the ages of three and twelve years, and may be mistaken for tuberculous hip disease if careful radiography is not employed; it is not very uncommon. There is often a history of injury some months beforehand, but syphilis, rickets, and anomalies of ossification have all been called in to explain its origin, probably without justification. A low grade infection with attenuated pyococci of the rheumatic type may be causative, but this is as yet non-proven. Radiography (R.S., Fig. 23) reveals that the head of the bone consists of a flattened, laterally expanded, fragmented epiphysis; the fragments ultimately fuse, so that the head of the femur develops into a permanently expanded or flattened cap, encroaching along the upper aspect of the neck towards the trochanter. Many cases of congenital dislocation of the hip show after reduction a flattening and fragmentation of the head exactly similar to that seen in coxa plana.

The **Symptoms** are a gradual onset with but little pain, moderate lameness, and slight limitation of movement, especially of internal rotation and abduction. The muscles around are somewhat atrophied, and the joint is irritable and liable to attacks of pain, if much used or strained. Slight shortening of the limb occurs in some cases. The condition is usually unilateral, but both sides may be involved, and the boy is apparently in perfect health. The disease progresses over a period of years to a cure, but osteo-arthritis is likely to ensue.

Treatment consists in limitation of walking and weight-bearing by recumbency, or by the use of a walking calliper; but it is quite an open question whether anything is really gained in this way.

Disease of the Sacro-iliac Joint.

Tuberculous disease of this joint is met with most commonly in adults, but rarely in children. It may commence in the synovial membrane, but is frequently the result of mischief starting in the pelvic bones, especially the ilium. The **Pathological Anatomy** calls for no description, inasmuch as it follows the ordinary course of tuberculous disease.

The **Clinical Signs** consist of pain and a sense of weakness in the lower part of the back, increased by standing, walking, or any movement—such as coughing, sneezing, and the like—which calls the flat abdominal muscles into sudden action and drags on the ilium. It is of a very unpleasant character, a sensation as if the pelvis were coming to pieces being experienced by the unfortunate individual.

* H. Platt, *Brit. Journ. of Surgery*, vol. ix., 1922.

Owing to the fact that the lumbo-sacral cord passes in front of the articulation, pain is often referred to the gluteal region or down the leg. Movements of the limb cause pain if the pelvis is not supported, but can be freely performed if the pelvis is steadied. Compression together of the innominate bones, or their forcible separation, is the means of demonstrating most effectually the existence and situation of the pain. The patient is unable to stand or to put any weight on the affected limb, and hence limps during walking, allowing his body to lean forwards, and making use of a stick. There is apparent lengthening on the affected side, but on measurement from the anterior superior spine to the internal malleolus the leg is found to be of the same length as its fellow. This appearance is due to the fact that the whole innominate bone is tilted downwards and forwards, so that the anterior superior spine is at a lower level and more prominent than that on the opposite side. The region of the synchondrosis is often swollen, puffy, and tender; whilst after a time abscesses form, which may either point immediately over the articulation, or burrow upwards into the lumbar region, or forwards into the iliac fossa, or downwards into the pelvis, opening perhaps in the ischio-rectal fossa. The last is a most serious complication, since it is almost certain to introduce a pyogenic element.

The **Diagnosis** needs to be made from sciatica, hip disease, spinal disease, and some other sources of pelvic pain. *Sciatica* is known by the character of the pain, which shoots down the back of the thigh in the course of the great sciatic nerve, which may be distinctly tender on pressure. There is no apparent elongation of the limb, and compression together of the pelvic crests is painless. From affections of the *hip-joint*, sacro-iliac disease is recognized by the fact that, if the pelvis is supported, the thigh may be moved in all directions without great discomfort; whilst compression of the pelvis in hip disease causes no pain. Moreover, in the advanced stages of hip disease there is apparent or real shortening and deformity, conditions never noticed in the sacro-iliac affection. From *spinal disease*, the diagnosis should not be difficult if a careful examination of the spine and pelvis is made. When pain is the most marked symptom, the surgeon must exclude other possible sources—*e.g.*, rectal or uterine carcinoma; it is a useful rule to remember that in all such cases a rectal or vaginal examination should be made. It is quite possible in certain cases of sacro-iliac disease to detect a fulness on the anterior wall of the synchondrosis.

The **Prognosis** is not necessarily unfavourable if asepsis is maintained; the admission of pyogenic bacteria constitutes the main danger. In young women it may lead to subsequent deformity of the pelvis and trouble in parturition.

Treatment in the early stages consists in absolute rest in bed, with the application of a pelvic support, and attention to the general health. Abscesses may be dealt with in the usual conservative fashion—viz., by aspiration, tapping or drainage—but it is sometimes necessary to lay them freely open, and deal with the diseased

bone by scraping or gouging it away, allowing the wound to heal by granulation. Occasionally the posterior part of the iliac crest in the neighbourhood of the posterior superior spine must be removed in order to gain access to the diseased area; this may be accomplished by the chisel or trephine through a vertical incision, and excellent results often follow this proceeding. In a certain number of cases immobilization of the joint has been secured 'by introducing a tibial graft across the sacrum under the erector spinæ muscles from one posterior superior spine to the other' (Verrall).* The two iliac bones are thus tied together and steadied without encroaching on the infective material within the joint (Fig. 344). The results have usually been satisfactory.

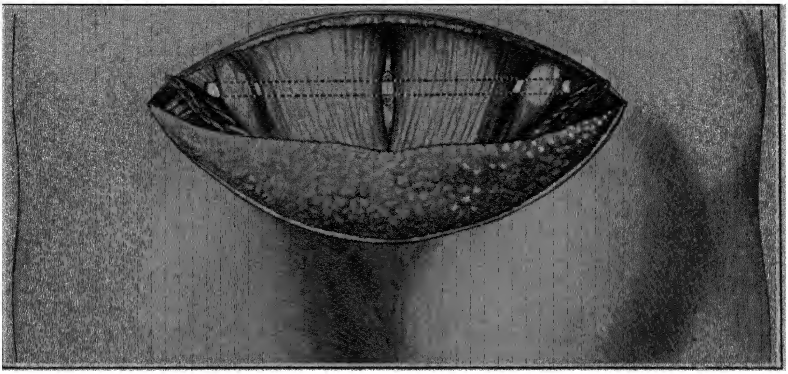


FIG 344.—VERRALL'S OPERATION FOR IMMOBILIZATION OF THE SACRO-ILIAC JOINT.

The bone graft is seen passing through the posterior part of the innominate bone on each side and lying deep to the erector spinæ muscles.

Sacro-iliac Strain.—This term is applied to a tender and painful condition of one or both sacro-iliac joints, which may render standing and even lying uncomfortable, and is a genuine source of back-ache. It usually occurs in women, and may have some relation to the pelvic movements which admittedly occur in parturition; in other cases it is attributed to strain, and may be due to some slight displacement of the ilium. When the position of the sacrum in relation to the pelvic circle is considered—viz., that it is slung on the upper wall with a natural tendency to drop forwards—the strength of the ligaments passing between it and the spine must be great, inasmuch as they transmit the weight of the trunk. Displacement can obviously be very slight, but it is suggested that in this condition the upper part of the sacrum usually swings backwards on its third segment as an axis. If this be so, the lumbar curve is lessened, the back becomes straight, and the sacral nerves

* *Clinical Journal*, February 3, 1926.

are dragged on. The pain varies from a slight ache to a severe crippling sensation, and is referred partly to the joint, partly to a spot just to the side of and below the umbilicus, and so may suggest appendicitis. **Treatment** consists in attempting replacement of the ilium by hyper-extending the thigh with the patient in the prone position. Replacement is sometimes accompanied by a definite click. The buttocks are then compressed together by strapping or a strip of webbing, or in bad cases by encircling the pelvis, trunk, and upper parts of the thighs in plaster of Paris for a few weeks. In intractable cases fixation by a bone graft, as suggested above, may be employed.

Excision of Joints.

Excision of joints is an operation which at the present time has been to a large extent replaced by other procedures—*e.g.*, arthroplasty (p. 761), or its necessity has been obviated. It has, however, a place in modern surgical practice, and in suitable conditions is useful and beneficial. The chief articular lesions for which excision, partial or complete, may be required are as follows: (1) For various forms of injury in the neighbourhood of joints where ankylosis is likely to follow, and either interfere seriously with the utility of the joint or fix it in a bad position: the shoulder and elbow are the joints most frequently dealt with in this way; (2) for some forms of congenital or old-standing dislocation which cannot be otherwise remedied; (3) in the later stages of acute arthritis to prevent ankylosis; (4) in tuberculous arthritis, where conservative treatment has failed to cure the disease, or where it is advisable to deal with it in the earlier stages in order to shorten its course; (5) for ankylosis of certain joints, consecutive to arthritis, especially if in a bad position; (6) for osteo-arthritis in special regions.

The results to be attained necessarily vary in the different joints, and according to the particular cause. Sometimes ankylosis in a good position is all that can be expected, in others a freely moveable pseudarthrosis; in some cases the removal of certain diseased tissue is the primary object of the operation, whilst in others no disease is present. All these varying conditions must be taken into consideration in determining the nature and extent of any excision.

In a small textbook like this we must perforce limit ourselves to a description of the methods most commonly adopted, and refer students to special works on Operative Surgery for further details.*

Shoulder.—The patient lies on the back, the shoulder projecting somewhat over the edge of the table, and with a sandbag beneath the scapula to steady it. The arm being slightly rotated inwards, an incision is made from a point midway between the coracoid process and the acromion, extending downwards and outwards for 3 or 4 inches through the fibres of the deltoid muscle (Fig. 345, D). It is better to incise the deltoid than to pass between it and the pectoralis major, the cephalic vein and accompanying artery being thus

* See Treeves and Wakeley, 'Handbook of Surgical Operations,' Cassell and Co., 1930.

uninjured The wound is thoroughly opened up by means of retractors, and the bicipital groove looked for, an incision is made along its outer border, and the long tendon of the biceps, if still present, turned out, and held to the inner side by a blunt hook A twig of the anterior circumflex artery will here be divided, and need a ligature. The arm is now thoroughly everted, and the tendon of the subscapularis and the anterior part of the capsule, with which it is incorporated, freely divided; where practicable, the attachments of the muscle to the bone should be separated subperiosteally, a proceeding presenting no difficulty where inflammation has previously existed. The arm is now inverted and held downwards by the side of the table, so as to bring the great tuberosity into view; the muscles attached to this process are dealt with in a similar way, and the upper part of the capsule freely opened The head of the bone is then protruded into the wound, and removed by the saw. It will often suffice to apply the saw obliquely through the substance of the tuberosity; this is to be preferred to removal of the whole tuberosity by a

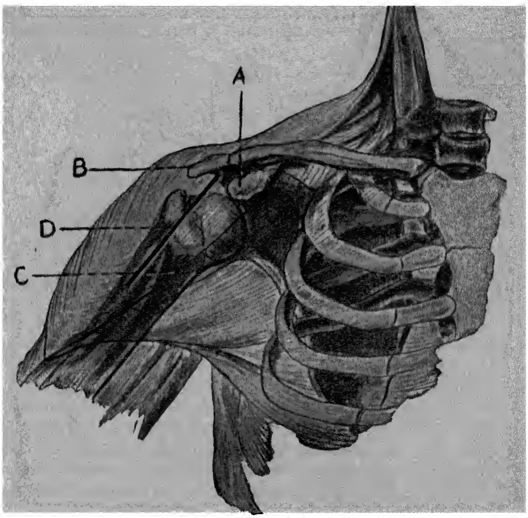


FIG. 345.—INCISION FOR EXCISION OF SHOULDER.

A, Coracoid process; B, tip of acromion, C, intermuscular line between deltoid and pectoralis major; D, incision.

horizontal incision at a lower level. The synovial membrane and glenoid cavity are dealt with as circumstances may dictate, and it is often advisable to make a counter-opening through the posterior axillary fold for the insertion of a drainage-tube; the anterior wound can then be entirely closed, In applying the dressing, care must be taken to put a good pad in the axilla, so as to keep the arm from being drawn forcibly inwards by the muscles attached to the bicipital groove There is no need to commence passive movements before the end of the first week. Fibrous union usually results, and the movements of the shoulder are generally very good, with the possible exception of abduction.

Excision of the Elbow may be required for simple or compound fracture-dislocation, or for subsequent ankylosis, especially if the limb is in a bad position, for tuberculous arthritis, and possibly in the later stages of acute arthritis. The best plan of operating is as follows. A single longitudinal incision, 5 inches in length, is made in the middle line of the posterior aspect

of the joint, extending for equal distances above and below the tip of the olecranon, and a little to the inner side. The limb is held across the patient's body, the surgeon standing on the affected side. The incision extends through the substance of the triceps down to the bone. The origin of the flexor carpi ulnaris and the inner half of the triceps tendon are detached, and the hollow between the olecranon and the internal condyle cleared, the knife being kept close to the bone, and the soft parts effectively retracted. By this means the ulnar nerve escapes injury, and, indeed, is often not seen at all. The internal lateral ligament should be divided, and the common origin of the flexors detached from the front of the inner condyle. The outer half of the joints is then dealt with in a similar way, the anconeus being divided close to its insertion to the ulna, the continuity of the triceps with the deep fascia covering it being also maintained. The origin of the extensor muscles is separated from the back of the outer condyle, and the external lateral ligament severed. The joint can now be freely opened by dividing any of the fibres of the posterior ligament which remain intact, and the denuded ends of the bones protruded from the wound. The lower end of the humerus is thoroughly cleared, and the articular surface removed, the section passing through the centre of the olecranon fossa. The olecranon, together with the upper articular surface of the coronoid process and the head of the radius, are next sawn off, care being taken to draw aside and protect the soft parts by retractors, especially those covering the ulnar nerve. The synovial membrane can be dealt with as may be necessary. Even if the head of the radius is free from disease, nothing is gained by leaving it intact, since ankylosis is very likely to follow unless plenty of bone is removed. As a general rule, a gap of 2½ inches should intervene between the divided ends of the bones, but the interposition of a flap of fascia between the bone ends enables the surgeon to take away less bone. The wound is carefully sutured, and a drainage-tube inserted for a few hours. The limb is kept on a hinged angular splint for a week, by which time union of the external wound should be complete, but the position is altered each day. After a week, the splint may be dispensed with, and the limb kept at rest on a pillow, free passive movement, both angular and rotatory, being daily practised. Considerable attention is needed in order to obtain a good result, but in a successful case every movement of the joint is perfectly restored. As a rule, the lower end of the humerus develops two lateral bony processes, like malleoli, within the grasp of which the upper rounded ends of the radius and ulna are able to move.

The **Wrist-joint** is only excised for extensive tuberculous disease when abscesses and sinuses are present. Ankylosis of the articulation, though a troublesome condition, is not sufficiently so to require such treatment. In the majority of cases an arthrotomy of the scope indicated at p. 742 suffices to give good results; only rarely is a more complete excision required, and that associated with the name of Lister is the best. For a full description, larger textbooks must be consulted.

The **Hip-joint** is rarely excised for conditions other than tuberculous disease, and even for this it is but seldom required. There are two chief methods of operating, the anterior and the posterior.

1. Excision by the *anterior method* is carried out as follows: The incision extends from immediately below the anterior superior spine vertically downwards for 3 or 4 inches. It passes between the tensor fasciæ femoris and sartorius muscles superficially, and between the glutei and rectus deeply, a small arterial twig from the external circumflex being divided at this stage. The neck of the bone and capsule of the joint are exposed, and the latter is freely incised along its attachment to the anterior intertrochanteric line, so as to allow of the admission of the finger, whereby the joint can be explored. The neck of the bone is cut through *in situ* by means of an Adam's osteotomy saw, the incision through the bone being placed obliquely downwards and inwards. The head of the bone is now either prised out of the acetabulum by an elevator or grasped by lion forceps and twisted out, a matter easily accomplished where the articular structures are diseased, but a proceeding of some difficulty in the normal joint of a cadaver. As much of the infected synovial membrane as

possible is clipped away with scissors, and the acetabulum scraped, if necessary. The external wound is either closed, with the exception of an opening for a drainage-tube, or packed with 'bipped' gauze. The limb is put up in a position of abduction so as to keep the neck of the bone in the acetabulum.

2 Excision by the *posterior method* is at the present day so seldom required that it seems unnecessary to describe it here (p. 770).

The **Knee-joint** is excised for tuberculous disease, osteo-arthritis, or deformity due to osseous or fibrous ankylosis in a bad position. A horseshoe-shaped incision is made, extending from the back of one condyle to the other, reaching downwards nearly as far as the tubercle of the tibia. The limb is flexed, the ligamentum patellæ divided, and the joint opened. The skin and subcutaneous tissues are then separated from the anterior surface of the patella, which may be at once removed by a curved incision above it, communicating on either side with that already made below, the subcrureal pouch of synovial membrane being also removed during this dissection. The flexion is now increased, and the lateral ligaments divided; by this means the interior of the joint is exposed, so that the attachments of the crucial ligaments to the tibia can also be severed. The lower end of the femur is then cleared of diseased synovial membrane, so as to allow of the application of a broad excision saw. The usual rule given as to the direction of the saw-cut in the bone is that the exposed bony surface left after removing its articular end should be absolutely horizontal, supposing the patient to be standing upright; some surgeons prefer to make the sections so that the limb shall be left slightly flexed and in-kneed, a position which greatly adds to the subsequent comfort of the patient. To accomplish this the saw must be applied parallel to the articular surface—*i.e.*, at right angles to the axis of the body, not of the femur, and with a slight upward slant from before backwards The bone should be partially sawn through by a side-to-side movement, but the posterior surface of the condyles should be divided by raising or depressing the handle of the instrument, so that the structures lying behind in the intercondyloid notch are not encroached upon. Sufficient bone should be sawn off in the adult to include the greater part of the articular cartilage, but as little as possible consistent with removing all the disease, otherwise the limb is shortened to such an extent as to interfere with its subsequent usefulness. The head of the tibia is then protruded, and cleared from the neighbouring soft parts; it is held absolutely vertical, and a saw applied in a horizontal position, the bone being divided from before backwards All diseased synovial membrane is dissected away, special attention being directed to the posterior aspect of the joint. Hæmostasis having been effected, the bones are fitted together, and, if considered advisable, secured in position by thick silver wire, nails, or screws, or by an autogenous bone peg, if wire is employed, it should be introduced horizontally through the bones from side to side rather than antero-posteriorly. The limb is placed in a half-box splint or in one made of Gooch's material reaching from the ankle to the hip; in this it remains until sound healing has occurred, after which an immovable case either of plaster of Paris or water-glass is kept on for eight or ten weeks.

The **Ankle-joint** requires excision so seldom that it is unnecessary to describe the operation.

CHAPTER XXIV.

INJURIES OF THE SPINE.

THE spinal cord is protected from injury in a most complete and efficacious manner. (*a*) Its position between the bodies and the laminæ with the spinous processes arising therefrom is itself mechanically advantageous, since, whether the spine is forcibly flexed or extended, the cord remains midway between the points of chief compression or extension, and hence in a position of rest. (*b*) The buffer-like action of the intervertebral discs, and the varying curves of the column, serve to distribute some part of any force that reaches it. (*c*) There is ample space in the spinal canal, in which the cord with its membranes is slung by prolongations of dura mater around the issuing nerves, whilst the cord itself hangs loosely within the dura mater, suspended by the ligamenta denticulata, and surrounded by cerebro-spinal fluid. (*d*) The cord terminates, in an adult, at the lower border of the first lumbar vertebra, a spot well above the junction of the fixed base and the moveable upper part, a point where the effect of jars and wrenches is mainly felt. (*e*) Nature has, moreover, introduced a whole series of buffers and other means of preventing shock to the spine when a person falls on his feet—*e.g.*, the arches and elasticity of the foot, the changes in direction of the bones at each joint, the inter-articular cartilages of the knee, etc.

The parts of the spine most exposed to injury are those where a fixed and moveable portion meet—*e.g.*, the dorsi-lumbar and the cervico-dorsal regions. Moreover, the upper part of the dorsal curve, which projects backwards, is relatively a weak spot, and fractures are not at all uncommon about the fourth dorsal vertebra. The close proximity of the head explains the frequency of lesions about the upper cervical region.

Sprains of the spine are very common accidents, a fact not to be wondered at, when its complicated muscular and ligamentous arrangements are considered. They are produced by any sudden or unexpected movements, such as falls, especially from horseback, railway accidents, and the like. The injury affects most frequently mobile parts of the spine, *e.g.*, the cervical and lumbar regions, and may be limited to either ligamentous or muscular structures, or may involve both. The resulting **Signs** are simply those of a severe but localized trauma—viz., pain, tenderness, and perhaps a little swelling or bruising; the subjective phenomena are much increased by movement, so that the spine is kept rigidly quiet. If only the posterior muscles or interspinous ligaments are involved, pain is elicited by flexion of the spine, as it puts these structures on the stretch; active extension is also painful, but passive backward flexion is painless. Similarly unilateral lesions are productive of pain on

stretching the injured structures. If the trouble is limited to the external muscles and ligaments, no further consequences are likely to arise; but when the ligamenta subflava are lacerated and the spinal canal is thus opened, pressure symptoms may arise from blood finding its way into the canal outside the dura mater, leading possibly to a temporary or permanent paraplegia. Inflammation of the damaged fibrous tissues may extend to the meninges and cord, and cause organic disease. Moreover, in patients of a tuberculous temperament spinal caries may follow such injuries; syphilitic or malignant disease has also been known to ensue.

In the *cervical* region, sprains may occur as a result of severe blows on the head, causing rupture of the inter-transverse ligaments, and the displacement may be so great as to simulate dislocation. The head and neck are held immoveable and rigid, and there is often considerable loss of power, the patient being sometimes unable to lift the head spontaneously from the pillow. Sprains in the *lumbar* region are very common, both as a consequence of overlifting, when the quadratus lumborum is most likely to be affected, and as a result of railway injuries, when they are often associated with nervous symptoms (p. 789). The back is kept fixed and rigid, the patient being unable to turn or stoop without pain. Sometimes hæmaturia results from injuries in the lumbar region, arising from an associated contusion of the kidneys.

Treatment.—The patient should be kept at rest, and fomentations applied to the injured part. When the painful or inflammatory symptoms have disappeared, massage with stimulating liniments is needed. In the severer cases the individual should be kept in bed for six or eight weeks, and in the cervical region some form of mechanical support may be subsequently necessary. The appearance of inflammatory symptoms involving the meninges calls for even greater care; the patient should then be kept as much as possible in the prone position, and a spinal icebag applied. The onset of paraplegia, due either to hæmorrhage or inflammatory exudation, would raise the question of laminectomy (p. 794).

Penetrating Wounds of the Spine are, fortunately, uncommon in civil practice, being generally due to stabs with pointed instruments, such as bayonets, or to gunshot wounds. They occasionally result from falls, the unfortunate individual becoming impaled on area railings, branches of trees, etc. The **Symptoms** produced are: (*a*) those due to the wound in the soft parts, which may also involve the peritoneal and pleural cavities, or damage to some of the viscera; in the neck, the vertebral artery is exposed to injury from this type of accident, leading to serious hæmorrhage; (*b*) various forms of fracture, the cord being compressed by fragments of bone which have been driven inwards, or by extravasated blood; (*c*) those due to laying open the spinal membranes—*e.g.*, loss of cerebro-spinal fluid, which in itself might prove fatal by draining the cerebral cavity, and so causing pressure on the base of the brain, or at a

later date may determine the patient's death by setting up diffuse septic meningitis (p. 788); and (*d*) those due to wounds of the spinal cord, which depend upon whether the cord is completely or incompletely divided, upon the level or segment of the lesion, and upon the actual area damaged in an incomplete division; thus a hemisection of the cord will produce the Brown-Séquard syndrome (p. 794). The effects of a total transverse lesion at different levels of the spine are given at p. 792. Of course, the cord may escape entirely, nerve roots or trunks only being involved, and in the lumbar or sacral regions the mischief may be limited to the cauda equina.

Treatment consists in exploring thoroughly the wound under an anæsthetic, removing foreign bodies or displaced fragments of bone, and attempting to render it aseptic. Wounds of the vertebral artery or other structures are dealt with *secundum artem*, and special attention is naturally given to the cord and its membranes. Should the dura mater have been opened, and the cord have escaped injury, an attempt may be made to close the wound in the meninges, and the patient should subsequently be kept in the prone position and with the head low, so as to prevent, as far as possible, the escape of cerebro-spinal fluid. If the cord itself is divided or lacerated, it is useless trying to unite it, since its function in conducting impulses from the brain downwards is inevitably destroyed. Where, however, the cauda equina has been injured, it is perfectly justifiable to lay open the spinal canal to a sufficient extent to expose the divided nerve trunks, and then to suture them.

Fractures of the Spine.—The spine may be broken as the result of (*a*) *direct violence*—*e.g.*, a fall on the back over some projecting body, such as a carpenter's bench or a railing, or a blow on the back with a heavy stone or with a swinging baulk of wood, or a gunshot wound. This type of accident may involve any part of the spine, and, excluding those arising from gunshot, is less frequent than the class next to be described. Of necessity, the spine breaks at the point struck; the posterior parts of the vertebræ are most likely to be damaged in this form of injury. (*b*) Fractures are also due to *indirect* violence, then usually occurring in the lower cervical or upper dorsal regions. They are caused by forcible acute flexion of the spine, as by a fall downwards with the head doubled up, or by taking a 'header' in shallow water, or when a man, being driven under a bridge, omits to stoop, and so is caught between the arch and the cart, or sometimes by the fall of a heavy weight on the back of the neck or shoulder. The spine may break across more or less cleanly at its weakest point, or the lesion may be limited to one or two bodies, which are crushed and broken. The latter type (compression fracture) is often limited to the bodies; the former usually involves injury to the cord.

Fractures of the spine may be divided into two main classes, according to whether or not they are complete—that is, according to whether the continuity of the column is destroyed or not.

(A) **Incomplete Fractures** may be met with in various forms, and are most frequently due to direct violence.

(i.) *Fracture of the Spinous Processes* rarely occurs except in the lower cervical or dorsal regions. In the upper cervical region the spines are short and retracted to allow of extension of the head, whilst in the lumbar they are also short, but very strong. The fracture is almost always due to direct violence, and is characterized by the signs of a local trauma, together with great mobility, perhaps crepitus, and irregularity in the line of the spines. The broken fragment is occasionally much depressed, and may even cause paraplegia by being driven into the spinal cord.

(ii.) *Fracture of the Laminæ* is not an uncommon accident, always resulting from direct violence. If only one lamina is broken, the signs are not very distinct, and cord symptoms are rare. When both laminæ yield, the posterior part of the neural arch, carrying with it the spinous process, is very likely to be depressed to a sufficient extent to compress the cord and give rise to paraplegia. Crepitus is often obtainable, and a gap in the line of the spinous processes can usually be felt.

(iii.) *Fracture of the Transverse Processes* is occasionally met with in the lumbar spine, and is frequently not diagnosed, the symptoms usually being attributed to myalgia.

(iv.) *Partial Fractures* through the bodies are not very uncommon, and take the form either of an incomplete fissure with little or no displacement, or of a compression fracture. The latter results from falls on the head or shoulders with the spine flexed, as in falls from horseback, or from being blown up, as by gas explosions or shell bursts in military operations. One or more vertebræ may crumple up more or less, with or without displacement, but usually without loss of continuity. There may be some irregularity of the spine, with tenderness over the spinous processes, but a definite diagnosis can only be reached by very accurate and clear stereoscopic radiography. Pain and rigidity are experienced, with a variable degree of nerve-root irritation, and the condition may be followed by traumatic spondylitis (p. 814).

In any of these cases symptoms of involvement of the cord may arise, either immediately from concussion, or at a later date from hæmorrhage, and is then sometimes of the gravitation type (p. 788).

Treatment consists in keeping the patient at rest in bed for a time until the immediate pain and tenderness have disappeared, and then a well-moulded spinal support must be worn for a year or more until the risk of further developments has passed. Definite displacement recognized radiographically may justify attempts under an anæsthetic to reduce the same, or even operative measures. Symptoms due to compression of the cord will be discussed later (p. 791).

Non-recognition of this type of accident is one of the causes of the persisting backache which so often follows accidents to the spine, where no gross lesion can be detected. Slight displacements of the bodies of the lumbar and dorsal vertebræ, ~~presumably accompanied~~

[redacted] presumably accompanied by slight unrecognizable fractures, can also be demonstrated radiographically now and then, and cause traumatic spondylitis on the one hand, or be the physical basis of numberless nerve symptoms, often designated as traumatic neurasthenia, on the other. Nerve-root phenomena may also be prominent (p. 439).

(B) **Complete Fractures** are usually associated with displacement and loss of continuity of the spinal column, and hence are often termed **Fracture-Dislocations.** They result either from direct or indirect violence, and are most common in the lower cervical or upper dorsal region. There is always a tolerably extensive lesion (Fig. 346); thus, the spinous processes and laminæ may or may not be fractured, the ligamenta interspinosa, supraspinosa, and subflava torn. the articular processes fractured in the lumbar and dorsal

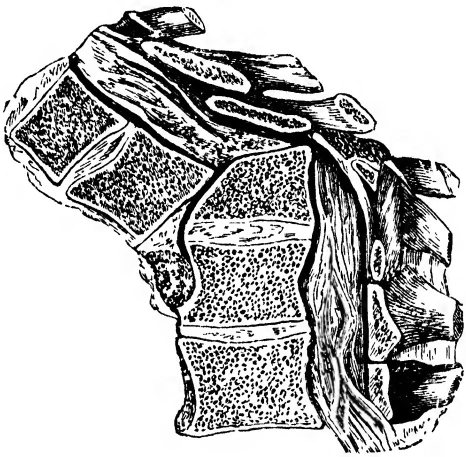


FIG. 346.—COMPLETE FRACTURE-DISLOCATION OF THE SPINE IN THE LOWER DORSAL REGION, WITH DISPLACEMENT AND COMPRESSION OF THE CORD.

regions, or displaced without fracture in the cervical, and either the intervertebral substance is torn across, or the bodies of one or two adjacent vertebræ are broken, thus severing the spine into two halves. The upper or movable portion is usually driven forwards over the lower or more fixed fragment, and impaction or comminution is often present. The spinal cord is compressed between the upper end of the lower fragment and the laminæ of the upper fragment, and although the displacement may be naturally remedied by the falling back of the bones into position ('recoil'), yet the effects of the crush on the cord are usually irremediable. In slighter cases the spinal membranes may be merely punctured by a splinter of bone, or hæmorrhage may occur either within the membranes, or outside them in the fatty theca vertebralis. Ex-

cessive indirect violence may lead to an associated fracture of the sternum.

The **Signs** of a complete fracture are usually very evident, consisting of local pain, swelling, and bruising, and a certain amount of angular deformity, although the latter often disappears when the patient is laid flat on his back for transport to his home or to the hospital. It may be possible to elicit crepitus if the parts are not impacted, but all unnecessary movement should be avoided for fear of adding to the injury of the cord. Paraplegia below the part injured is present in most cases, and with it some amount of general shock. When the cord is disintegrated or divided, complete flaccid paralysis of the parts below is developed, together with anæsthesia, and a fatal issue often occurs at an early date from toxæmia, preceded by septic cystitis or sloughing of the nates. Lesions of the cervico-dorsal region in which the cord is extensively damaged quickly become dangerous to life in that they cause paralysis of the muscles of respiration, with the exception of the diaphragm, and hence predispose to static pneumonia. Complete lesions at or above the level of the fourth cervical segment are usually fatal at once from involvement of both phrenic nerves. The general mortality of fracture-dislocations of the spine is about 70 per cent. The special phenomena of paraplegia at different levels are dealt with at p. 792.

The **Prognosis** of these cases turns largely on the situation of the injury and the amount of mischief sustained by the cord. The higher the lesion, the greater the danger, although patients with paraplegia from cervical fracture may live for years, and even partially recover, if the cord has not been totally disintegrated.

The **Treatment** naturally varies with the character of the case. The patient is carefully placed on a prepared bed, the greatest gentleness being used in handling and lifting him, for fear of increasing the damage to the cord. The bed must be firm, though not hard; perhaps the best type to employ is a divided horsehair mattress (Fig. 25[illegible]) placed over fracture-boards; nothing more soft or yielding is permissible. Spring beds and wire-wove mattresses are most undesirable. A water-bed is required in the later stages, but should not be used at first, as it is scarcely firm enough. The shock resulting from the accident is treated in the usual way by warmth and, if need be, by stimulants; but it must be remembered that anæsthetic regions of the body can be easily blistered or burnt by hot-water bottles, unless carefully guarded by flannels. When reaction has occurred, a more thorough examination of the patient can be made, and the subsequent course of treatment decided on.

(*a*) In a small minority of cases, *operative treatment* is justifiable, and has for its object either the immediate fixation of the fracture (Albee's operation), or the relief of pressure on the cord (laminectomy). For details of these proceedings, see p. 794.

(*b*) When displacement persists owing to impaction of the fragments, *reduction* under an anæsthetic may possibly be undertaken, provided that the lesion is not in the cervical region, and the paraplegia not complete. Of course, if other internal injuries are present which render the case hopeless, nothing active should be done. Great care must be used in attempting reduction, since any undue violence may readily increase the mischief; in the lumbar region, however, considerable force may be employed without much danger. Whether reduction is accomplished or not, the further treatment must be directed in accordance with the indications given in the next section. Where the surgeon fails to reduce the deformity, it may sometimes be advisable to make gradual weight extension from the feet or neck.

(*c*) In many cases, as soon as the patient is laid flat on a bed, the displacement remedies itself, especially if the spine has been comminuted, and then the treatment must be *symptomatic*, as also after reduction or operation where the paraplegia persists or is only slowly recovered from. He is kept in bed, absolutely flat, and with the head low; perhaps some form of mechanical support—*e.g.*, a plaster of Paris or leather jacket—may be desirable, but its application is a matter of difficulty unless a special table is available, and in the early stages it does but little good. Food is regularly administered, and at first must be light and readily assimilable.

The chief care of the attendants must be directed to the skin, bladder, and bowels. *Bedsores* are extremely liable to form on all points of pressure, and hence the nates and heels must be carefully guarded (p. 126). In turning the patient to attend to the nates, the body must be rolled over as a whole, and not merely the pelvis twisted. When the *bladder* is paralyzed, the urine may be withdrawn by a catheter. One of the chief dangers that the patient runs is from the supervention of septic cystitis, and the extension of the inflammation upwards to the kidneys. This is generally due to infection from without, and the greatest care must be taken to prevent it. The penis should be thoroughly purified, and in the intervals between instrumentation wrapped in a dry sterile dressing. Only soft rubber catheters are employed, and these must be boiled before use, and lubricated with some sterile material. Should infection occur, the bladder is irrigated twice daily with some mild antiseptic, such as Condy's fluid, boric acid, boro-glyceride (1 in 20), or sanitas (1 in 20), whilst urotropine or some other urinary antiseptic is administered. Probably, in spite of all precautions, the condition will persist, and prove fatal from extension to the kidneys. Recognizing this fact, it has been recommended by some authorities to allow the condition of distension with overflow to occur in order to avoid the passage of catheters; the urine is permitted to flow away into sterile flasks frequently changed. It has, however, been proved that massage of the prostate, as recommended by the late J. R. Murphy, is effective in determining reflex micturition, and if suitable male attendants are available, this method should always be

employed, but it is useless if once catheterization has been started. The *bowels* are always obstinately constipated, and must be opened either by purgatives or simple enemata.

Under such a régime the patient may gradually recover, but more often succumbs to chronic toxæmia or exhaustion. Occasionally he may live for a long time, although paralyzed, not unfrequently developing some amount of reflex micturition if the lumbar centres are not involved. Varying degrees of restoration of power in the lower limbs are observed if the cord is not completely divided.

Dislocations of the Spine can only occur in the cervical region. The reason for this depends partly on the greater fixity of the dorsal and lumbar vertebræ, and partly on the direction of their articular processes. In the cervical region these look mainly upwards and downwards, with a slight slope forwards and backwards, so that it is not difficult for one to slip over the other; in the dorsal and lumbar region they are placed nearly vertically, and dislocation is impossible without a serious concurrent fracture, although slight displacements may quite well occur (p. 781).

Any part of the cervical region may be the seat of a dislocation. The *occiput* has been displaced from the *atlas* in a few cases, resulting in sudden death; but if incomplete, life has been prolonged for a few hours or days. Dislocation of the *atlas from the axis* has followed blows on the neck, or has been the cause of death in hanging, whilst the attempt to lift a struggling child by the head has sometimes led to this calamity. In almost all cases the odontoid process has been fractured or the transverse ligament torn, causing instant death from compression of the cord, owing to the head and atlas slipping forwards. Lateral displacement from rotation has also been observed, the cord symptoms then being of a milder type.

Dislocation may occur between any two of the *lower five cervical vertebræ*, but perhaps most frequently between the fifth and sixth. It is most commonly unilateral, and almost invariably the result of forcible flexion of the head and neck, together with rotation. The head and upper portion of the spine are displaced forwards and twisted, so that the articular process of the upper vertebra involved slips over the front edge of the lower opposing articular process, and becomes caught by it so that it cannot return.

When the lesion is *unilateral*, the head is turned towards the opposite side, and more or less fixed, and the ear is raised. There is no evidence of compression of the cord, although tingling and neuralgic pains are caused by pressure upon and stretching of the nerve-roots in the intervertebral notch. The spinous processes may be irregular and displaced laterally, and the line of the transverse processes is similarly altered. Such signs are, however, very difficult to make out in thick necks, and in consequence the condition is sometimes overlooked and left unreduced, giving rise to deformity, and permanent neuralgia may result. In early cases *replacement* may be accomplished. The patient is anæsthetized, the body fixed, and traction made upon the head and neck away

from the side of the dislocation, so as to unlock the edges of the articular processes. Reduction may be effected with a definite snap or catch. In old-standing cases an operation may sometimes be attempted to relieve pressure on the nerves, but it is impossible to replace the bones.

If the condition is *bilateral* and complete (Fig. 347), there is a more serious involvement of ligaments, and the anterior displacement of the upper segment is such as to lead to grave pressure upon the cord and paraplegia. Occasionally, however, the lesion is only partial, and then the cord may escape without immediate injury, owing to the large size of the canal in this region, although hæmorrhage and inflammation may subsequently cause grave symptoms. *Treatment* is of but little avail in most of the cases of complete double dislocation, since probably the cord is irretrievably damaged; but when paraplegia is incomplete, it is possible that benefit may arise from early interference. Replacement by traction on the head with the neck flexed may be first carefully tried, and, failing that, open reduction should be attempted. After stripping the muscles from the bones, the surgeon will see the two cartilage-covered surfaces of the upper articular processes of the lower vertebra standing out clearly behind the laminæ of the displaced bone. Upward traction on the head may now again be made, and reduction thus secured; but if this does not succeed, a small portion of the upper margins of the exposed articular processes is excised in order to allow of the unlocking of the bones. If the whole processes are removed, reduction is easier, but recurrence is certain, as it is impossible subsequently to fix the parts.

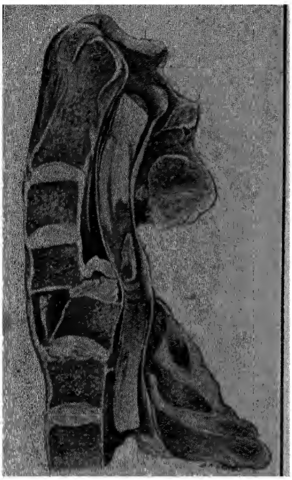


FIG. 347.—DISLOCATION OF THE CERVICAL SPINE (COLLEGE OF SURGEONS' MUSEUM.)

The fourth cervical vertebra is displaced forwards, projecting in front of the fifth, the body of which compresses the spinal cord.

Affections of the Cord associated with Spinal Injuries.

Injuries of the spinal column are frequently associated with, or followed by, conditions affecting the cord and its membranes which may lead to the gravest results, even when the local lesion to the spine has been comparatively slight. These are frequently blended with one another in the most puzzling fashion, but for simplicity's sake we shall discuss them here separately without attempting to describe the various combinations.

Direct Concussion.—This condition may be due to severe blows on the back, which do but little damage to the spinal column, or may be caused by accidents which lead to the infliction of greater mischief, but without any serious displacement of parts. There can be little doubt that the condition is due to the presence of minute extravasations in the cord.

The *Symptoms* produced are those of loss of function of that portion of the cord situated below the point struck. The patient is usually prostrate from general shock, and the reflexes are absent. Death may be caused at once by a blow in the cervical region, or varying degrees of loss of power and sensation may be produced in any or all of the limbs. In the lumbar and dorsal regions the patient complains of weakness of the legs, and loss of control over the sphincters. Priapism never occurs in simple concussion. The temperature of the body is depressed; the pulse is rapid and weak, and the respirations are shallow. The *Prognosis* is generally good, the patient recovering after a time; it is unusual for organic disease to follow.

In the *Treatment*, absolute rest to the spine is of the greatest importance, and this should be maintained if possible in the prone position, so as not only to diminish static congestion, but also to remove any pressure on the spine, and to allow topical applications to be made. A spinal icebag may be applied, or the back may be dry-cupped, and the patient is kept on a low diet. The bladder and bowels may require attention, but no special drugs are necessary.

Spinal Hæmorrhage can here only be discussed as resulting from injuries. It occurs, however, apart from traumatism, and then most frequently in young persons between the ages of ten and twenty. The bleeding may take place either into the cord itself or outside it, and hence the two following varieties are described:

(*a*) **Intramedullary Hæmorrhage,** or spinal apoplexy (*hæmatomyelia*), is usually met with in the lower cervical region, and results from some accident that causes acute flexion. Extravasation into the cord is rarely extensive, and may occur in the form of one clot, generally not larger than an almond, or more commonly in many spots, the grey matter being more or less ploughed up. The white matter is compressed, and sometimes the blood bursts through it into the subarachnoid space. Should the patient survive, secondary degenerations are established, and run the usual course. The patient is suddenly struck down with a more or less complete paraplegia, and with perhaps pain in the back, shooting round to the chest, and early followed by a rise of temperature. The paraplegia consists of a flaccid paralysis of the arms due to destruction of these centres and of the legs from interference with the descending columns. Some degree of recovery follows, especially in the legs, but the parts supplied from the damaged portion of grey matter—*i.e.*, the arms—are likely to remain paralyzed. In slighter cases only involving the grey matter, the arms alone may show signs of paralysis from the

first. The *Diagnosis* of hæmorrhage turns on the rapid onset of paralytic symptoms without spinal irritation; fever may ensue for a few days, and if the cervical region is affected, extreme contraction of the pupil (myosis) may result from destruction of the cilio-spinal centre. There is retention of urine and fæces, and priapism is common. The *Prognosis* depends on the size and situation of the clot; hæmorrhage in the cervical region may be immediately fatal by interference with the respiration, whilst in the lumbar region it is unfavourable on account of the effect upon the sphincter centres. The outlook is best when the dorsal portion of the cord is affected. The *Treatment* is the same as was indicated for direct concussion, whilst the administration of a few doses of ergot may be beneficial.

(*b*) **Extramedullary Hæmorrhage** (*hæmatorachis*) is a more frequent complication of spinal injuries, such as sprains or limited fractures, than the former. The blood is extravasated between the bones and the dura mater, especially in the cervical region, but is occasionally found within the dura. The symptoms are those of spinal irritation —*e.g.*, pain, hyperæsthesia, spasms, cramps, etc.—followed after a time by loss of power in the muscles supplied from the damaged area, or by 'gravitation paraplegia' (Thorburn), which gradually extends from below upwards, causing death by asphyxia, the whole series of phenomena being afebrile. In intramedullary hæmorrhage the symptoms of paralysis are more evident, and those of irritation less marked. If a diagnosis is made, ergotin may be injected and ice applied to the spine, or even laminectomy performed to relieve pressure; later on, prolonged rest is required to permit of the absorption of the clot.

Spinal Meningitis may spread downwards from the head, or commence as a local affection. Two forms are met with resulting from injury:

(*a*) **Acute Spinal Meningitis** is usually seen in conjunction with a similar condition of the cerebral meninges, for even though it follows an infected wound of the spine, it quickly spreads upwards and the cerebral manifestations give the chief colour to the picture. It affects the arachnoid and pia mater (leptomeningitis), which lose their polish and become hyperæmic, whilst an abundant effusion containing leucocytes and bacteria, and even lymph or pus, occurs; should the patient live, organization of lymph may lead to extensive adhesions. *Clinically*, the disease is ushered in by a rigor and runs a markedly pyrexial course. The special symptoms attributable to the spinal trouble are: pain in the back, deep-seated, boring and severe, increased on all movements, and often extending down the limbs or around the body; rigidity of the spine and limbs, accompanied by painful cramps and muscular spasms; extreme hyperæsthesia, especially of the legs, and increased reflex excitability. Limitation of the disease to the spine may be associated with the appearance of paraplegic symptoms and death from toxæmia, bed-sores, or bladder troubles; more usually the patient dies from coma, due to the cerebral infection. *Treatment* must be undertaken along

lines similar to those employed for the cerebral form of meningitis—viz., drainage of the effusion by repeated lumbar puncture, and possibly the introduction of suitable anti-sera into the meninges after withdrawal and bacteriological examination of the exudate. Symptomatic treatment is required in order to gain sleep and to protect the nates, bladder, and rectum. The spinal icebag may be of some service in relieving pain.

(*b*) **Chronic Meningitis** is usually localized, and may involve either the arachnoid and pia mater (leptomeningitis), or be mainly limited to the dura mater (pachymeningitis). It may originate as a chronic affection, or is the sequela of an acute attack, and is more likely to supervene in syphilitic individuals. The membranes become thickened, and adhesions to the cord may occur; a chronic sclerosing myelitis is frequently associated with this affection. The *Symptoms* are those of localized pain and rigidity in the back, increased on all movements, and accompanied by shooting pains and hyperæsthesia, and perhaps muscular pains and cramps. The reflexes are usually exaggerated, and vesical complications may follow. *Treatment* consists in prolonged rest with counter-irritation in the form of blisters or the button cautery applied to the back; mercury and iodides are administered internally.

Spinal Myelitis may follow injuries of the spine, either as a direct consequence of depressed or displaced bone, or from hæmorrhage; it may also be caused at a later date by extension of inflammation from the meninges, or result from compression by lymph, pus, granulation or cicatricial tissue, or callus. It may be acute or chronic. In the former the cord becomes red and softened; the nerve elements are destroyed, and finally replaced by cicatricial tissue if the patient live long enough. In chronic cases the connective tissue becomes thickened, and the nerve structures compressed and disintegrated, whilst the meninges are always adherent and thickened.

Symptoms.—**Acute** myelitis is evidenced by the presence of pain in the back and along the course of the nerves arising from the inflamed area, soon followed by paraplegic symptoms, if these are not already present as the result of the injury. Slight irritative symptoms sometimes precede the paralysis. **Chronic** myelitis gives rise to a great variety of symptoms, but those most marked are a gradually increasing motor weakness, going on to paralysis, together with various sensory phenomena ending in anæsthesia, and there is trouble with the bladder and rectum.

The *Treatment* of each of these conditions is mainly symptomatic.

Spinal, or Traumatic, Neurasthenia (*Syn.* : **Railway Spine**).—Cases are not uncommonly met with in which, although there has been no direct injury to the spinal column or cord, and no immediate symptoms of importance, the fact is manifestly demonstrated in various ways that considerable commotion and disturbance have been produced in the nervous system. Railway accidents are the most common cause of this condition, but it may arise from any

jar to the spinal column, or even after injuries to other parts of the body. The essential features are cerebral, and not spinal. The reason why railway accidents are so often responsible for this state is that the forces concerned are very great, and the collision unexpected, so that the muscles and ligaments are taken at a disadvantage, being off their guard, whilst the shock, terror, and mental disturbance are also important factors. Ligamentous and muscular lesions—*i.e.*, sprains and strains—are the usual local phenomena produced by such accidents.

In the majority of cases the symptoms are mainly due to excessive irritability and weakness of the spinal and cerebral centres, constituting a condition of nerve prostration, or **Neurasthenia,** and the history will usually be somewhat of this type: The individual at the time of the accident is thrown from side to side, or severely shaken, but does not lose consciousness, and, although feeling somewhat dazed, is able to alight without help, and may even assist others. He perhaps continues his journey, and goes to his business, but finds in the course of a few hours that his back is painful, his head aching, and that he cannot apply himself to his work. He returns home and goes to bed, sends for his doctor, who will probably prescribe rest and bromides. His condition remains for a time unaltered; he complains of pain and tenderness over certain regions of the spine, especially the lumbar, and is unable to walk, or to undertake any serious mental or physical effort, whilst all excessive sensory stimuli, such as a bright light or noise, are unusually disturbing. Neuralgia is often present; the pulse is weak; the urine may be retained or dribble away; sexual power is lost, and the temperature may be for a time subnormal. Accommodative asthenopia (or the inability to accommodate for near objects), resulting in a temporary condition of presbyopia, is also a marked feature in many of these cases. Al the symptoms are aggravated by mental excitement and exertion, such as are produced by the necessary interviews with doctors and solicitors pending the financial compensation by the railway company. The immediate improvement which often follows the satisfactory settlement of his claim for damages is not necessarily due to imposture, but may result from the removal of mental tension and anxiety.

This condition of neurasthenia may develop immediately after the accident as an acute condition, the patient lying helpless and prostrate, or more often chronically, as in the more common type of case described above. To it, however, is frequently added a considerable element of **Hysteria,** in the form either of an acute attack of hysterics, or of a chronic unconscious exaggeration of the sensory symptoms. If the patient is examined in the supposed hyperæsthetic area whilst his attention is distracted, possibly no pain will be complained of.

The *Prognosis* is generally favourable, the patient recovering in time, but in a few instances permanent effects may be produced, or even a condition of chronic myelitis.

In the *Treatment*, a good deal of care is needed to judge rightly when the period has arrived for encouraging movement rather than rest, and thus to prevent the patient from developing a condition of chronic invalidism. Rest in bed is to be recommended at first, bromides given in moderation, and fomentations applied locally. Later on, friction with liniments and massage should be employed, and when all chance of secondary inflammatory disturbance is at an end, movement should be encouraged, and change of air advised, whilst a course of strychnine and iron may be administered.

Paraplegia has been mentioned so frequently in discussing the injuries of the spinal column and cord that a more detailed reference to it is essential.

Causes.—(1) It may arise as the direct result of the injury, and then is due to displacement of bone or hæmorrhage. (2) It comes on at a slightly later date as a consequence of extramedullary hæmorrhage (localized or of the gravitation type), and that usually without pyrexial phenomena. (3) It may be due to the pressure of inflammatory exudate—*e.g.*, lymph or pus—and then is late in its development, and preceded by the pyrexia and irritative phenomena of that condition. (4) It may develop late in the case from the pressure of callus or cicatricial adhesions around the cord or its membranes (peri-pachymeningitis).

The **Phenomena,** whether due to injury or inflammation, are those of a total transverse lesion of the cord, absolutely destroying one segment. The following symptoms result:

1. Flaccid paralysis of the muscular area supplied by the destroyed segment, followed by rapid atrophy, reaction of degeneration, and loss of reflexes in this particular group of muscles.

2. Flaccid paralysis of all the muscles supplied by the segments below that which has been destroyed. The trophic condition remains normal, at any rate, but later when secondary descending degeneration in the antero-lateral columns has occurred, the muscles become contracted, tense, and rigid (late rigidity).

3. Complete anæsthesia of the sensitive area supplied by the destroyed segment, and of all the sensitive areas below, and loss of the muscular and thermal senses.

4. A narrow zone of hyperæsthesia is found at the upper level of the anæsthetic area, due to the irritation of the nerve-roots at the site of injury (girdle-pain).

5. Total loss of all the reflexes, deep and superficial, occurs, with the exception of the tonic contraction of the sphincters of the bladder and rectum. In the course of two or three weeks an extensor response appears to gentle plantar stimulation, and possibly this may in time elicit a 'mass reaction' of the muscles of the leg and even of the abdominal wall. The superficial reflexes may reappear, and occasionally the deep ones, but in the presence of septic complications they often disappear, and the limb relapses into a flaccid state, the extensor reflexes vanishing first.

6. Vasomotor paralysis combined with trophic disturbances in the parts which are paralyzed.

7. Visceral changes, especially in the bladder and rectum. In the *Bladder* two stages occur: (*a*) The period of complete *retention*, due to the interference with the voluntary control, permitting the tonic action of the sphincters to be maintained, as a result probably of the micturition centre being situated in the sympathetic hypogastric mesenteric plexuses. The bladder becomes distended, and unless relieved by catheterism, incontinence with a full bladder follows. (*b*) After a while the bladder wall begins to regain its tone, and small acts of expulsion of urine occur, although the catheter may still be required. In time periodic reflex micturition develops, in which a varying quantity of urine collects in the bladder, and is unconsciously and involuntarily expelled. This is the typical ***automatic bladder*** of a paraplegic patient, and occurs even in some cases where the lesion is limited to the cauda equina.

Cystitis is only too liable to follow and is of a grave nature, possibly associated with sloughing of the vesical mucosa and hæmorrhage, and terminating in an ascending pyelo-nephritis and uræmia. The cause is almost always septic catheterism, occurring in an individual of low vitality and in tissues of diminished resistance.

The ***rectum*** is also affected in the direction of incontinence of fæces and marked constipation. This condition has to be carefully watched, as it will certainly predispose to bed-sores.

Phenomena of Paraplegia at Different Levels. 1. **At the Upper End of the Sacrum.**—Total transverse lesions at this spot are not uncommon; they involve the cauda equina and cause paralysis of the sacral plexus. The effects produced are: (i.) Paralysis of all the muscles of the legs, except those supplied by the anterior crural, the obturator, and the superior gluteal nerves, whilst the perineal and penile muscles are also affected. (ii.) Anæsthesia of the penis, scrotum, perineum, lower half of the gluteal region, and the whole of the legs, except the front and outer parts of the thigh, which are supplied by the cutaneous branches of the anterior crural, and the region supplied by the long saphenous nerve. (iii.) The bladder and rectum are influenced as described above.

2. If the lesion is situated in the **Dorsi-lumbar** region, or passes through the lumbar enlargement, which corresponds to the twelfth dorsal and first lumbar vertebræ, there is complete paralysis of the muscles of both limbs, including those passing to them from the trunk; total anæsthesia of the legs, gluteal and perineal regions, and possibly the lower part of the abdomen.

3. In the **Mid-dorsal** region the same phenomena are met with, but to them are added a more extensive region of anæsthesia, limited above by a hyperæsthetic zone, which feels like a tight painful girdle round the waist. Paralysis of the flat abdominal muscles also occurs and is a most important addition to the gravity of the case, for all straining movements are thereby prevented, and thus coughing is embarrassed and defæcation hindered. The gases developing from

the stagnant fæces accumulate and cause distension of the belly (meteorism), and thereby respiration may be seriously impaired. The diaphragm, moreover, is hampered in its action, since the lower ribs cannot be fixed or steadied, and hence its contractions tend to pull them inwards, instead of increasing the dimensions of the thoracic cavity.

4. In the **Cervico-dorsal** region all these phenomena are present, but the anæsthesia extends over nearly the whole trunk, and the hyperæsthesia may involve the arms, whilst the intercostal and spinal muscles are also paralyzed, and there is some weakness of the hand-grasp. Respiration has to be carried on by the hampered diaphragm, with the assistance of a few of the accessory respiratory muscles in the neck, and hence is much impeded; if bronchitis is present, it will prove fatal by asphyxia in a few days from the inability to expectorate. Priapism is a marked feature of cervical paraplegia, as also contraction of the pupil from interference with the lower cilio-spinal centre.

5. In the **Lower Cervical** region the arms also become involved in both the paralysis and anæsthesia, and the patient is likely to die in thirty-six to forty-eight hours, or less, in a condition of hyperpyrexia. If the lesion is situated at or above the fourth cervical vertebra, instant death results from paralysis of the phrenics and consequent stoppage of the respiration. If the fifth cervical segment is involved, the arms are usually found completely paralyzed, lying by the side of the trunk. A lesion through the sixth segment causes the arms to be rolled out and abducted, the elbows being flexed and the hands supinated with the fingers semiflexed. Injury to the seventh segment results in the hands being half-closed, the elbows bent, and the forearms lie in a condition of pronation over the chest.

Death from Paraplegia, therefore, may arise from a variety of causes and at various periods. It may be immediate, from respiratory failure in lesions above the fourth cervical vertebra; or it may occur from accumulation of mucus or pus in the air-passages, when the lesion is in the upper dorsal region; or it may be delayed for weeks, or even months, and then be due to sloughing of the nates, or septic absorption from an inflamed or ulcerated bladder, which is often associated with suppurative pyelonephritis.

The **Prognosis** and **Treatment** both depend on the position and character of the lesion causing the paraplegia, and on the previous habits and condition of health of the individual.

Incomplete Division of the spinal cord is by no means uncommon, and opportunity of studying it has occurred frequently of late. In the majority of cases the early phenomena cannot be distinguished from those of a complete lesion, being due presumably to concussion, and consisting of: (*a*) Complete flaccid paralysis to the level of the lesion; (*b*) anæsthesia to a similar level; (*c*) loss of all reflexes, deep and superficial; and (*d*) retention of urine. Evidence of the partial character of the lesion may be forthcoming in a few days or weeks by the reappearance of some degree of motion or sensation, or by

spasticity of muscles. Difficulty arises when the only early change is one of the reflexes; the initial loss is replaced by a reappearance of the deep reflexes (patellar jerk and ankle clonus), of an extensor plantar response and a maintained loss of superficial reflexes. Sphincter symptoms are not to be trusted as giving any indication of the completeness or not of the cord lesion, for automatic micturition may develop even in hopeless lesions of the cauda equina.

Hemisection of the Cord.—A lesion involving one lateral half of the spinal cord below the cervical region is not very unusual in military work. The resulting symptoms are usually known as the Brown-Séquard syndrome, and consist in: (*a*) On the side of the lesion motor paralysis of the leg with an extensor plantar reflex and active tendon reflexes, together with sensory symptoms referable to the division of the posterior column, viz., loss of the sense of position and of vibration sense, etc.; (*b*) on the side opposite to the lesion there is no motor paralysis, but there is loss of cutaneous sensation to temperature and pain.

Albee's Operation, originally introduced with the object of fixation of the damaged vertebræ in tuberculous disease of the spine (p. 812), has of late had its scope enlarged to provide fixation in other conditions—viz., (1) in fractures of the spine with persistent non-union; (2) in progressive scoliosis, where the condition is increasing and resists treatment, or where it has attained such a degree as to cause constant pain and gross deformity; and (3) with suitable modifications for spondylolisthesis (p. 488), where rest is insufficient to combat the symptoms.

In fractures it is not often required, but when partial fractures exist which do not unite, and are a cause of continuous pain and discomfort to the patient, it is a justifiable and useful proceeding. The patient is anæsthetized in the prone position, and an incision made over the affected area, the spinous processes being cleared of muscles, etc., on either side. The spines are then split longitudinally by a sharp osteotome. A suitably shaped tibial bone graft is cut by means of a twin saw driven by an electric motor (Fig. 292), and wedged in between the divided segments of the split spinous processes; it is fixed in place by suturing the muscles and fasciæ of the back over it. The patient is of course immobilized in a plaster bed for a time, and the graft usually unites well, thereby determining the fixation required. It is not a serious operation in careful hands, and good results may be anticipated.

Laminectomy is an operation for the removal of the laminæ and spinous processes of one or more vertebræ, in order to relieve pressure on the cord, whether due to depressed bone, abscess, granulation tissue, excessive callus, cicatrices, or tumours. The operation consists in making a longitudinal incision in the middle line of the back, extending to the spinous processes; the muscular and tendinous structures are then cleared from the posterior aspect of the vertebræ as far as the transverse processes, a proceeding usually attended

with considerable hæmorrhage, which can be checked, perhaps, better by hot sponge pressure than by attempting to secure the individual vessels. The neural arches are then examined for injury, etc., and those which seem to be most affected removed by cutting pliers, Hey's saw, or laminectomy forceps. The posterior aspect of the membranes of the spinal cord is thus exposed, and the various conditions which may be present are dealt with according to circumstances. In this place we have merely to consider the use of this operation after injury to the spine. For its employment in other conditions, see Chapter XXV.

It must be remembered as a fundamental principle that repair is impossible after the spinal cord has been divided, or any one segment totally disintegrated, and hence, if it is certain that a total transverse lesion of the cord has been caused by an accident, it is absolutely useless to operate except to relieve pain due to root pressure. This question as to the special features of complete and incomplete lesions has already been alluded to, but one would again emphasize the fact that it cannot be absolutely settled in the early stages of the case, as it is at first impossible to say whether the symptoms are due to concussion, hæmorrhage, or bony pressure. Fortunately, delay does not appear to be so prejudicial to the patient's welfare as one might at first expect, and many cases are on record in which a good result was obtained even after months. One is therefore justified in waiting a while in doubtful cases. In spite of this, however, there will always be a certain number of patients in whom it is a matter of doubt as to whether or not any benefit will accrue from operation. The final decision under such circumstances depends on the general state of the patient.

Apart from these doubtful cases, the following are generally admitted as being suitable for operation: (1) Penetrating wounds or fractures with displacement which involve the spine below the first lumbar vertebra; the cauda equina is present below that level, and not the spinal cord, and it is reasonable to treat it in the same way as one would treat a single peripheral nerve; (2) when the injury is mainly limited to the neural arch, which has been driven in by direct violence; (3) in all cases of bilateral dislocation of the cervical spine where the patient is not moribund; (4) if paraplegia arises with or without inflammatory symptoms, when an interval has elapsed since the accident; the pressure in such cases may be produced by blood or inflammatory exudations, and benefit may possibly arise from the operation; if, however, it is due to a total transverse myelitis, no good can follow. (5) When symptoms of irritation or paralysis supervene at a later date, from contraction of cicatrices around the cord or its membranes (peri-pachymeningitis), or from excessive callus formation, laminectomy may be performed with good hopes of a successful result.

CHAPTER XXV.

DISEASES OF THE SPINE.

Spina Bifida.

By **Spina Bifida** is meant a condition of imperfect development of some portion of the posterior aspect of the spine, with or without a similar affection of the spinal cord and membranes.

It must be remembered that the spinal cord is developed as a linear involution of the epiblast, the edges of this medullary groove growing up and uniting so as to include a passage lined with epithelium, and subsequently known as the central canal. The cord is gradually separated from the overlying skin by an intrusion of mesoblastic elements, from which the vertebræ, together with the spinal muscles and ligaments, are developed. The ossification of each vertebra originates in three main centres—one for the body, and one for each half of the neural arch, whilst epiphyses are developed as plates above and below the body, as also for the transverse and spinous processes.

The following are the chief forms of spina bifida:

1. A **Myelocele** results from non-closure of the primitive medullary groove. It is characterized by the appearance in the lumbo-sacral region of a raw surface, which consists of the spread-out structures of the cord, at the upper part of which opens the central canal. The condition is incompatible with life, and the child, if not stillborn, as is usually the case, does not live beyond a day or two.

2. A **Meningocele** (Fig. 348) is characterized by a protrusion of the membranes, containing cerebro-spinal fluid, through a defect in the posterior walls of the vertebræ, the spinal cord and nerves being in their normal position. This variety is not very common.

3. A **Meningo-Myelocele** (Fig. 349) is due to a development of fluid within the membranes which remain adherent to the skin, the spinal cord or nerves of the cauda equina passing down the posterior aspect of the cavity as a strap, and the nerves traversing and perforating the sac to reach the intervertebral foramina.

4. A **Syringo-Myelocele** (Fig. 350) arises from a distension of the central canal of the cord, the posterior portion of which usually remains adherent to the skin, from which it has never been separated, owing to defective development of the mesoblastic tissues. The spinal nerves travel round the walls of the cyst in order to find their way to the intervertebral foramina. Trophic phenomena are nearly always a prominent feature of these cases.

Of these forms, the meningo-myelocele is that most frequently seen in living children, although, according to Bland-Sutton, the first is really the most common.

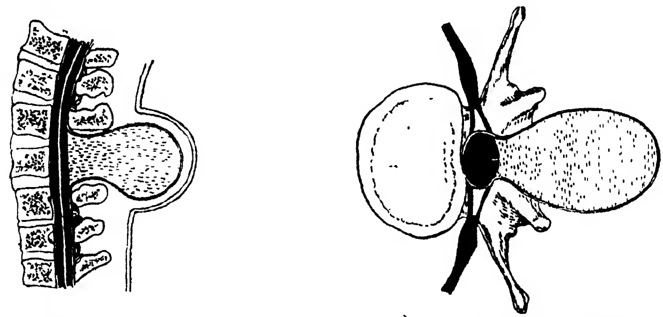


FIG. 348.—HORIZONTAL AND VERTICAL SECTIONS OF A SPINAL MENINGOCELE.

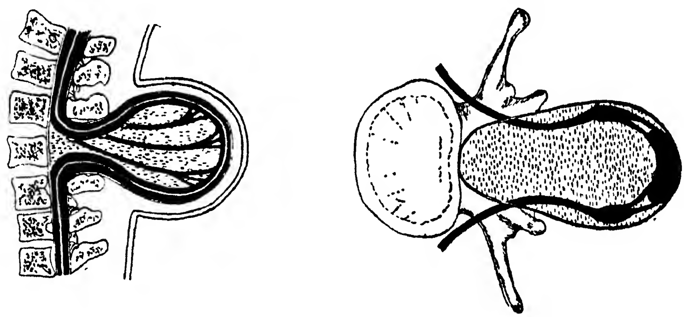


FIG. 349.—DIAGRAM OF A MENINGO-MYELOCELE.

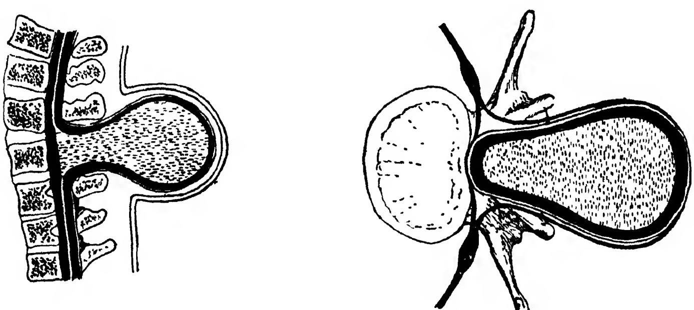


FIG. 350.—DIAGRAM OF SYRINGO-MYELOCELE.

Clinical Characters.—A spina bifida (except of the myelocele type) is recognized by the presence of an elastic swelling in the middle line

of the back (Fig. 351), most commonly involving the lower part of the spine; it may be covered by normal skin from which may arise an abnormal growth of hair, but usually that over the convexity is thin and translucent, and not unfrequently a number of small dilated vessels are seen coursing over it. On compressing this swelling, its size can sometimes be diminished, and then in infants distension of the anterior fontanelle may be felt, showing that the sac is filled with cerebro-spinal fluid; there is usually a distinct impulse on coughing or crying. The margins of the defects in the vertebræ can often be felt at the base of the swelling. Other deformities may be associated with spina bifida, especially hydrocephalus and paralytic talipes, whilst perforating ulcer, ankylosis of phalanges, and other trophic phenomena, are frequently developed at a later date.

Fig 351.—Lumbo-Sacral Spina Bifida, showing Deformities of the Feet.

The **Diagnosis** is usually evident, but sometimes in the cervical region a small tense meningocele is not readily recognized. Radiography may be of assistance in demonstrating the defects in the vertebræ.

The **Prognosis** of the case depends mainly on the thickness and character of the overlying skin. If it is thin and atrophic, as in many cases of meningo-myelocele, the sac is likely to give way, causing death from sudden escape of cerebro-spinal fluid or from infective meningitis. If the spina bifida is small, and covered with healthy skin and subcutaneous tissue, the patient may reach adult life, but even then trophic phenomena may supervene, possibly as the result of the presence of foci of nævoid tissue, which have been known to develop in the canal when the cord is absent. Occasionally a meningocele, with only a small aperture of communication with the spinal canal, is cured spontaneously by gradual growth of the bones.

Treatment.—Some cases are best left alone, the tumour being merely guarded from injury by the application of a suitable cap; but if the sac is thin and gradually increasing in size surgical intervention is absolutely necessary. Acupuncture or tapping through the healthier integument around the base, repeated perhaps several times, and followed by compression, may lead to a cure in favourable cases. Better results, however, are obtained by tapping, followed

by the injection of Morton's fluid (℞. Iodi, grs. x.; pot. iod., grs. xxx.; glycerinum, ad i.). A small quantity of the cerebro-spinal fluid is withdrawn, and then from half a drachm to a drachm of the iodine solution is introduced. It diffuses itself slowly, and its action is localized, so that if the child is kept quiet, and only semi-recumbent, its effect will be limited to the sac and its neighbourhood. Persistent leakage will need the application of a firm antiseptic compress; in many cases the injection needs to be repeated more than once.

Operative treatment is chiefly applicable in the meningocele type, and infants or those suffering from trophic phenomena do not stand it well. An incision is made over the sac, either in the middle line if the cord is not there, or to one side if it is. The child should be kept with the head low, so as to limit, as far as possible, the loss of cerebro-spinal fluid. In a meningocele, the membranes are cut away, after tying or suturing carefully the pedicle, and the spinal muscles drawn together, so as to create an extra protective barrier, in addition to the skin and subcutaneous tissues. When the cord runs down the back of the sac, it is freed by incisions on either side, and if it cannot be separated from the skin, the whole strip is replaced in the vertebral canal, the membranes are closed over it, and finally the muscles and skin. The results in the treatment of meningoceles have been most encouraging.

Spina Bifida Occulta is the term applied to a condition in which the posterior portion of the vertebræ is absent, but without any protrusion of the cord or its membranes. The overlying skin may be cicatricial in character, or a large growth of hair may arise from it; occasionally a lipoma develops in this situation, and by its growth compresses the spinal cord or drags upon it, and causes paraplegia. Unless such a condition is present, spina bifida occulta calls for no treatment, but an exploratory operation should always be undertaken when nervous phenomena supervene.

Congenital Sacral or Coccygeal Tumours.

The majority of these arise from what is known to embryologists as the *neurenteric canal*. In early fœtal life the neural and alimentary canals are continuous, the passage of communication being known by the above name. Ordinarily, it disappears entirely after the union of the proctodeum with the intestine, but evidences of its existence are occasionally met with, either in the form of a cicatricial dimple adherent to the tip of the coccyx (*post-anal dimple*), or as one of the following conditions:

(i.) A *dermoid cyst*, containing the usual mixture of sebaceous material and epithelial cells, and often a tuft of hair; it develops in the space between the rectum and coccyx, and may either project below or by the side of the coccyx, or open into the rectum; the tuft of hair may then find its way out of the anus. The cavity may actually communicate with the spinal meninges.

(ii.) A *congenital adenoma* of the post-anal gut (Fig. 352) is occasionally found in the same region. It is characterized microscopically by the existence of alveoli, lined by cuboidal epithelium, held together by connective tissue; it may attain a large size, but is quite innocent.

FIG 352.—CONGENITAL SACRO-COCCYGEAL TUMOUR OF ADENOMATOUS TYPE.

Various other tumours are met with in infants in this region, and the same title of congenital sacral or coccygeal tumour has sometimes been applied to them:

(*a*) A *spina bifida* of the meningocele type, which may communicate with the subdural space, or may have been shut off by a natural process of cure.

(*b*) A *lipoma* may also form here, and in some cases has simulated by its shape a caudal appendage.

(*c*) A partially-developed fœtus may be met with, enclosed within the subcutaneous tissues of the sacral region, and known as a *teratoma* (p. 244).

(*d*) A growth of a mildly malignant character, known as a *chordoma*, may also be found in this region, developing from notochordal tissue. A similar development is sometimes seen at the other end of the notochord—viz., in relation to the basi-sphenoid. It is encapsuled and lobulated, and may not only cause absorption of neighbouring bone, but also interfere with the pelvic viscera. The histological characters are somewhat indefinite and often of a mixed type.

Inflammatory Affections of the Spine.

I. **Acute Osteomyelitis of the Spine** is uncommon. It usually affects the mobile portions of the spine in young people, and may involve the bodies or the laminæ. It is characterized by severe pain in a localized portion of the back, and fever; deformity is not marked, since necrosis occurs, and not a gradually destructive caries. Abscesses form early, and when the arches are involved there is great danger of an extension of the inflammation to the spinal meninges, leading to a fatal issue. The prognosis is bad, owing to this latter complication, and the only possible treatment consists in early incisions to give exit to the pus. Sequestra can be removed from the back of vertebræ, but from the front only in the lumbar and cervical regions. A subacute form is occasionally met with, usually a metastatic infection with a primary staphylococcal focus. Treatment with a spinal jacket gives relief from the acute pain, and the prognosis is favourable.

II. **Tuberculous Disease of the Spine or Spinal Caries** (*Syn.* : **Pott's Disease, Angular Curvature**).—The above names are applied to a tuberculous disease of the vertebræ, originating almost invariably in their bodies, which are more or less destroyed, leading to the so-called 'angular curvature.' It was first accurately described by Percival Pott in 1779.

The **Causes** are much the same as those of tuberculous affections elsewhere, and, indeed, it is often associated with other manifestations of the same disease. It most frequently occurs in children under the age of ten years (75 per cent. of all cases), and of these it has been demonstrated that 60 per cent. are due to infection with the bovine type of tuberculous organism. It may, however, arise at any age, and equally in either sex. Any part of the spinal column may be involved, but the lower dorsal is by far the commonest. The cervical region is rarely attacked, except in children and young adults, whilst in adults the dorsi-lumbar vertebræ are the favourite seat.

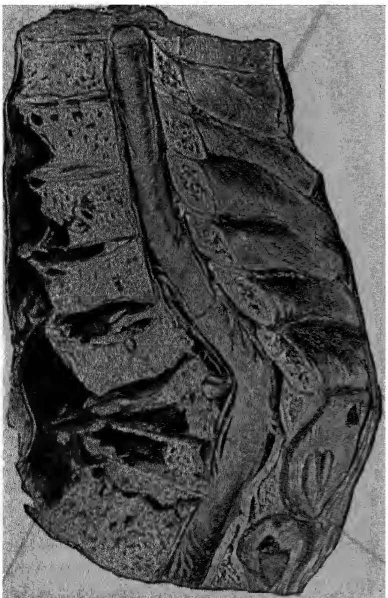


FIG 353.—TUBERCULOUS DISEASE OF SPINE, SHOWING DESTRUCTION OF THE BODIES OF THE VERTEBRÆ AND ABSCESS FORMATION BENEATH THE ANTERIOR COMMON LIGAMENT. (MODIFIED FROM SPECIMEN IN COLLEGE OF SURGEONS' MUSEUM.)

Pathological History.—The disease commences either as a periostitis or an osteomyelitis. The *periosteal* variety rarely occurs, except in adults. It involves the anterior surface of one or more vertebræ, and spreads under the anterior common ligament from one bone to another, whilst the intervertebral discs are also attacked and destroyed. The *endosteal* form is much the more common, and is almost invariably the type seen in children. The tubercle is deposited in relation with the plate-like epiphyses of the bodies, and produces its usual effect in softening and disintegrating the osseous tissue. The anterior parts of the bodies are affected more than the posterior, and hence deformity is common and nervous affections rare. The deformity is more or less of an angular type, due to the bodies falling together, either from the weight of the trunk, or from muscular action, or when the patient has been in the recumbent position from the cicatricial contraction which is associated with the healing of the granulation masses in the front of the bodies. The

disease spreads to adjacent vertebræ, either through the intervertebral discs which are destroyed in the process or by extension under the anterior common ligament, when it may become widely diffused, body after body being eroded, and the cartilages suffering even more than the bones (Fig. 353). In such a case the deformity is not angular, but rather of a general kyphotic nature. Occasionally the disease starts simultaneously in many foci, so that the bodies of several vertebræ become pitted and carious, without producing general destruction. In other cases the process is limited to the bodies and intervertebral discs of two adjacent vertebræ, the periosteum being but little affected. This variety is, perhaps, most common in the lumbar region, where the bodies of the vertebræ are large and permit a limiting zone of sclerosed tissue to form; it is also not uncommon in this situation to find definite sequestra in adults (Fig. 354). Unequal crumbling and falling in of the sides of the vertebræ will lead to lateral deformity, but this is not very common.

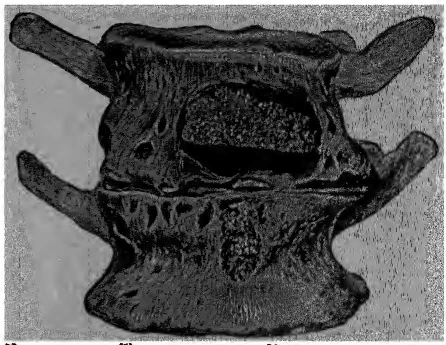


FIG. 354.—TUBERCULOUS DISEASE OF TWO LUMBAR VERTEBRÆ, SHOWING SEQUESTRUM ON THE ANTERIOR ASPECT, AND LATERAL THICKENING PREVENTING ANGULAR DEFORMITY. (COLLEGE OF SURGEONS' MUSEUM.)

Natural cure is effected by the bodies of the vertebræ falling together and becoming ankylosed, so that apart from treatment a deformed and immobile condition of the spine is the best result that can be anticipated. The new bone thus formed becomes in time sclerosed and very dense, and the synostosis also involves the spines and laminæ. In favourable cases this occurs without suppuration, but not unfrequently abscesses form. Occasionally the tuberculous process extends backwards through the body of the bone, so as to implicate the posterior common ligament, and symptoms from pressure on the cord may then arise.

In the upper cervical region the disease usually starts in the large joints, either between the occiput and atlas, or between the atlas and axis. For a time it may be limited to one side, but the body of the bone is attacked at an early stage, and the trouble then spreads to other joints. A special complication of this variety will be mentioned hereafter (p. 808).

The **Signs and Symptoms** produced by tuberculous caries of the vertebræ vary considerably in different situations, but for practical purposes may be described under the following five headings:

1. **Pain** is a constant and invariable accompaniment of the disease, although in the early stages it may not be specially prominent, being only elicited by careful examination. It is of two main types, the

local and the referred. *Local pain* is often not severe, but can usually be elicited by pressure or percussion over the spines, or perhaps more effectually by pressing upon the transverse processes so as to induce rotation of the vertebral bodies one on another. Movements of the spine, bending or twisting, are similarly painful, whilst the same result can be brought about by jarring the spine, as by a blow on the head or nates. *Referred pain* is produced by pressure upon, or irritation of, the roots of the nerves as they emerge from the intervertebral foramina; consequently its distribution is governed by the arrangement of the nerve-root area of the affected spinal segment (p. 439). If the lumbar region is affected, the pain is referred down the legs; in the dorsi-lumbar region it may follow the last dorsal nerve, and be noticed in the lower part of the abdomen, or in the gluteal region; in the lower dorsal region pain is referred to the epigastrium, children who are unable to differentiate its precise nature complaining of 'belly-ache'; in the cervico-dorsal region the pain often extends into the arms.

2. **Rigidity** of the spine is a constant accompaniment of Pott's disease. In the *early* stages it results from muscular spasm, the object being to fix and immobilize the painful part. If the lower portion of the spine is involved, the back is held stiff and straight, the patient abstaining from all movements which would bend or stretch it. Thus, in order to pick up an object from the floor, the knees and hips are flexed, and the patient gradually lets himself down with an absolutely rigid back into a sitting or squatting posture; the body is raised in a similar manner by resting the hands upon the thighs, the patient, as it were, climbing with extended arms up his own legs. In a small child rigidity in the dorsi-lumbar region can be demonstrated by laying him on his face with legs together, grasping the two ankles with one hand, and ascertaining the amount of movement in that region by lifting the legs from the table, and also by moving them from side to side; the other hand steadies the body above the suspected lesion. In a healthy child the legs can be elevated, and the spine bent back in the dorsi-lumbar region, nearly to an angle of 60°; whilst lateral mobility to the extent of 30° or 40° on either side of the median line is obtainable. When caries is present, neither of these movements can be made without including the thorax and dorsal spine. In cervical caries the patient steadies the head, and at the same time raises the shoulders by the help of the trapezius and sterno-mastoid muscles, whilst the chin is often supported by one hand, and the patient twists his whole body in order to look sideways.

In the *later* stages, when repair is taking place, or has occurred, rigidity of the spine is due to osseous ankylosis. After a cure has been established, compensatory movements of other portions of the spine mask to a certain degree the localized rigidity.

3. **Deformity** is necessarily present in almost all instances owing to the character of the reparative process. The amount of the deformity depends on many circumstances, and perhaps chiefly upon the number of vertebræ affected. Where only two bones are

involved, a true angular deformity may result, the body of the upper vertebra being welded to that of the lower, so as to produce a wedge-like mass; compensatory curves of the spine above and below enable the patient to assume the erect posture. When a large number of vertebræ are affected, the curvature is never angular, but the whole region becomes bent forwards, and that sometimes very acutely (Fig. 355). In the lumbar region (and to a less extent in the cervical) loss of the normal forward convexity is often the most marked feature, the vertebræ being piled, as it were, one above the other, so as to constitute an absolutely vertical column (Fig. 357). When the affection is limited to two lumbar vertebræ, there is usually little or no displacement, as the disease occupies the centres of the bones, so that the sides may escape altogether. In the dorsal region the deformity is usually well marked, as several vertebræ are often involved; the length and obliquity of the spinous processes make the posterior projection very considerable. In the cervical region there is rarely much deformity, owing to the small size of the vertebral bodies, but if several bones are involved, the head may be carried forwards and flexed, necessitating considerable compensatory changes in the dorsal, or even lumbar regions.

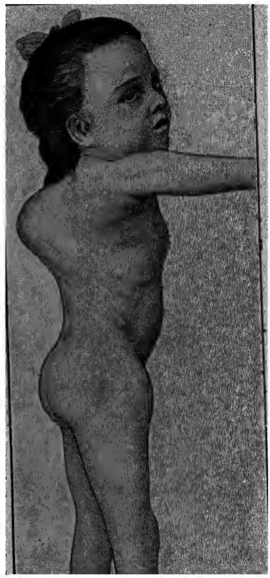


FIG. 355.—ADVANCED TUBERCULOUS DISEASE OF SPINE IN DORSAL REGION.

Secondary changes in the shape of the thorax accompany advanced cases in the dorsal region, the sternum becoming convex anteriorly so as to compensate for the diminished vertical measurement of the thorax, and the ribs crowded together. The lower floating ribs may, however, retain their normal position, and thus a horizontal groove may be produced corresponding to the line of the tenth rib. In such cases the patient becomes much stunted in growth and dwarfed, constituting the typical 'hunch-back.'

4. **Abscess** is the most serious result of spinal disease, for, owing to its deep origin, it often attains considerable dimensions before it is recognized or treated, whilst it is usually impossible to deal with the causative lesion in the bones. It is relatively more common in adults than in children. The pus collects primarily on the anterior aspect of the vertebræ beneath the anterior common ligament (Fig. 353), which may be stripped from the bones for a considerable distance. It thence finds its way to the sides of the bodies after perforating the ligament, and burrows in various directions, according to the portion of the spine involved.

In the cervical region a *chronic retro-pharyngeal abscess* is first formed; it pushes the posterior pharyngeal wall forwards, and may be detected from the mouth as an elastic fluctuating swelling, which, by its size, often leads to some difficulty in swallowing and breathing, whilst œdema of the glottis may be induced. Left to itself, it may burst into the pharynx and suffocate the child, or at best pyococcal infection follows, and the osseous lesion is thereby aggravated. Not unfrequently the pus finds its way to the side of the neck, behind the vessels and sterno-mastoid, being guided to

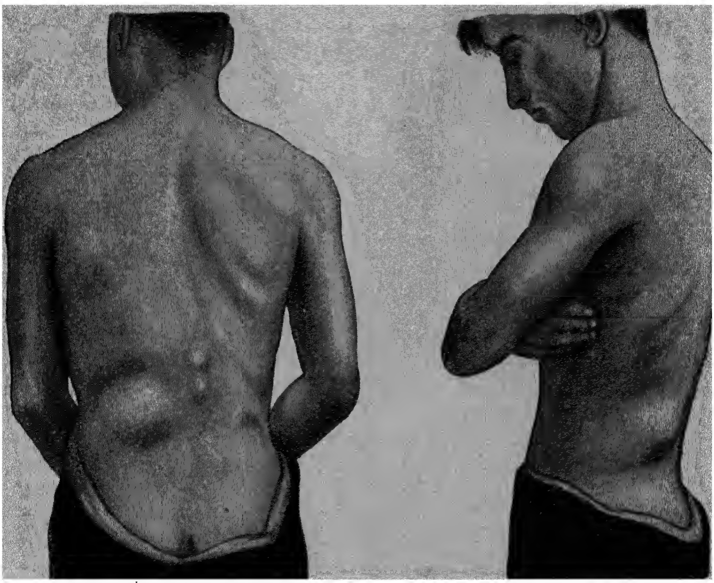


FIG. 356.—LUMBAR ABSCESS ARISING FROM TUBERCULOUS DISEASE OF THE DORSI-LUMBAR SPINE.

FIG. 357.—LUMBAR ABSCESS: LATERAL VIEW OF SAME PATIENT.

The projection of the spinous processes is evident, the lateral curve is possibly merely an associated or antecedent deformity, the loss of anterior lumbar convexity in Fig. 359 and the straightness of the spine are very characteristic.

the posterior triangle by the prevertebral fascia, behind which it is situated. Less frequently it pierces this fascia, and presents in the anterior triangle, or travels down towards the mediastinum, or along the brachial nerves to the axilla.

In the dorsal region, the abscess starts in the same way in front of the vertebræ, and usually extends backwards between the vertebral ends of the ribs to form a *dorsal abscess*, which points 3 or 4 inches from the spinous processes, and has an impulse on coughing. Sometimes it comes to the surface at the spot where the lateral

cutaneous branches are given off, and then they cause tuberculous disease of the ribs, leading to caries or necrosis, or even a localized empyema. In disease of the lower vertebræ, the abscess generally burrows downwards, passing under the ligamentum arcuatum internum of the diaphragm, and giving rise to a psoas abscess.

In disease of the dorsi-lumbar or lumbar regions, either a lumbar or a psoas abscess may result. A *lumbar abscess* (Fig. 356) is due to the passage backwards of the pus along the posterior branches of the lumbar vessels and nerves to the outer border of the erector spinæ, and usually presents superficially in Petit's triangle—*i.e.*, between the adjacent borders of the latissimus dorsi and external oblique muscles. It there forms a tense fluctuating swelling, with an impulse on coughing. A *psoas abscess* (Fig. 358) lies within the sheath of the psoas muscle, the pus being usually superficial to the muscular fibres, some of which are probably destroyed. It is often preceded by a condition of spasmodic contraction of the muscle with limited extension of the thigh, which may disappear after a period of rest. In time a resistant mass of a fusiform shape is felt placed deeply in the abdomen; as it enlarges, it usually burrows outwards under the fascia iliaca to form a tense rounded swelling in the iliac fossa (Fig. 359). It thence travels under Poupart's ligament, behind and external to the common femoral vessels, being constricted at this spot so as to form a narrow neck. The sac then expands behind the common femoral sheath, the vessels being often displaced forwards, and the vein flattened out and compressed. Thence passing along the tendon of the ilio-psoas, to the neighbourhood of the lesser trochanter, the abscess usually burrows amongst the adductor muscles, forming a large swelling on the inner side of the thigh, and comes to the surface at or near the saphenous opening to the inner side of the main vessels, and hence may be mistaken for a femoral hernia. Occasionally the pus follows backwards along the internal circumflex artery, and may point behind the great trochanter; in neglected cases the abscess has been known to extend down the leg, and has even been evacuated by the side of the tendo

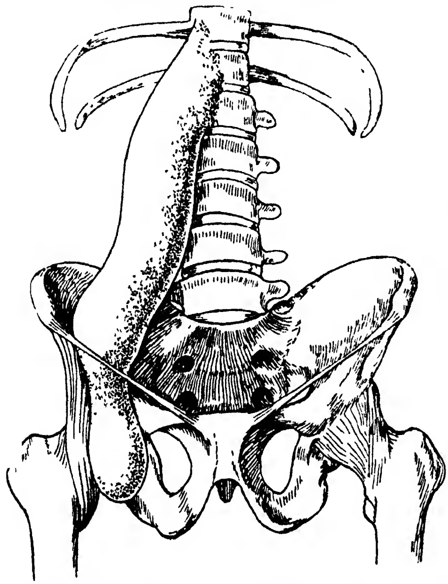


FIG. 358.—DRAWING TO SHOW A PSOAS ABSCESS IN RELATION TO SPINE AND PELVIS.

Achillis. In a few instances the pus finds its way into the pelvis, and then points in the ischio-rectal fossa, or possibly burrows through the sacro-sciatic foramen.

In the most typical variety—viz., with a pouch both above and below Poupart's ligament, communicating by a narrow neck—cross-fluctuation can be detected in the lower pouch by compressing the upper, or *vice versa*. There is, of course, an impulse on coughing in the portion below Poupart's ligament.

The constitutional disturbance associated with the formation of these abscesses is usually but slight, and there is no leucocytosis; perhaps there is a small rise of temperature at night, but if, as occasionally happens, auto-infection with pyogenic organisms occurs, this becomes more marked. As the pus comes to the surface, considerable pain may be experienced from the tension and irritation of the soft parts.

FIG. 359.—PSOAS ABSCESS POINTING IN THE ILIAC FOSSA AND BURROWING AMONGST ADDUCTOR MUSCLES.

5. **Nervous Symptoms** occur in about one out of every thirteen patients, and then generally in bad or neglected cases. They are scarcely ever due to the acuteness of the curve, but have been known to result from fracture of the spine, the integrity of which had been weakened by the inflammatory process. The usual cause is an extension backwards of the disease, so that a nodule or button of tuberculous material forms beneath the posterior common ligament, or pushes through it, compressing the cord against the laminæ, and actually invading the dura mater. Occasionally an abscess burrows backwards and compresses the cord, and then the symptoms may be relieved by opening the abscess even at a distance.

The effect produced varies with the rapidity and acuteness of the process. When the pressure is rapidly developed, granulation tissue springs up around and involves the theca, and a subacute myelitis ensues; but more frequently it is of a chronic or sclerosing type. The cord is then constricted or indented by the tuberculous mass, and perhaps reduced in size; its texture is firmer than normal, and the colour grayish. The onset of symptoms may be suddenly

induced by hæmorrhage or displacement of bone, but is usually gradual. The dorsal region (about the eighth vertebra) is most often involved, since there is plenty of space in the cervical region, and in the lumbar the cord has broken up into the cauda equina.

The symptoms arising from pressure on the cord must be distinguished from those due to irritation of, or pressure on, the nerve-roots. The latter causes neuralgic pain within the area of distribution of some nerve-roots, possibly in the later stages associated with anæsthesia (*anæsthesia dolorosa*), or a limited motor weakness if the anterior roots are involved. In compression of the cord the signs are usually of a paraplegic type, which come on suddenly or gradually. The latter is the more common, and the onset is at first marked by dragging of the toes on walking, the weakness increasing and spreading upwards, until all power is lost. Anæsthesia may or may not accompany the paralysis, but when it does, the limbs become flaccid, sphincter disturbance develops, and the deep and superficial reflexes are usually diminished or lost. If there is no sensory loss, the limbs are as a rule spastic, and sphincter disturbance is not a prominent feature. Spasticity is usually associated with active deep reflexes, extensor plantar response and absence of other superficial reflexes.

Tuberculous disease of the upper two vertebræ usually originates in one or more of the large articulations on either side of the atlas; if these joints become disorganized, displacement may occur at any moment, and in this way the occiput slips forwards upon the atlas, and may lead to gradual or sudden compression of the cord and consequent death. The disease sometimes spreads to the body of the axis, and by this means the odontoid process becomes detached, or the transverse ligament gives way; in either case, the weight of the head carries the arch of the atlas forwards, and death ensues at once from compression of the medulla.

Course of the Case and Prognosis.—Left to itself, the disease usually progresses more or less steadily, the bone lesion becoming gradually more marked, and abscesses are likely to develop. If treated efficiently, and taken in hand early, repair by ankylosis may be confidently expected. Even when an abscess forms, prolonged rest may lead to its disappearance, the fluid part of the pus being absorbed, and the solid elements becoming inspissated and dry, forming a putty-like mass lying on the front of the vertebral column; this may subsequently undergo liquefaction, probably owing to infection with pyogenic cocci, constituting what is known as a *residual abscess*. Should, however, the abscess burst or be opened, and become septic, symptoms of chronic toxæmia supervene, and the patient is sooner or later exhausted by the discharge, and dies from asthenia. If dealt with judiciously and sepsis avoided, the abscess may be cured, and if at the same time the spine is kept at rest, and suitable hygienic measures are adopted, the lesion in the bones is able to consolidate. The onset of paraplegia must not be looked on as rendering the case hopeless, since with prolonged

rest the paralytic phenomena usually disappear entirely. Sphincter control is regained first; sensation reappears, and finally motor power is restored. Septic cystitis and bedsores may of course arise as complications, and by their progress may cause death. As in tuberculous disease elsewhere, the patient also runs the risk of developing acute miliary tuberculosis, whilst other organs—*e.g.*, the lungs, brain, or kidney—may become affected. In spite of these possibilities, however, the prognosis is good as regards life in cases free from complications, and where suitable treatment is practicable.

The **Diagnosis** of spinal caries is rarely a matter of difficulty when the characteristic deformity exists, but in the early stages, when the displacement is not evident, or if there is only a very slight prominence of the spinous processes, it is likely to be mistaken for a simple rachitic or static curve; whilst if neuralgic pain is a prominent symptom, it may possibly be looked on as a case of spinal or intercostal neuralgia, or as rheumatism, or even be ascribed to renal affections. Tumours of the spine, such as cancer or hydatid cysts, syphilitic disease, and aneurismal erosion, also produce symptoms somewhat resembling those of spinal caries, and in adults it may be impossible from the local phenomena alone to determine which of these conditions is present; but a careful consideration of the general history and of the onset of the symptoms and a radiographic examination should settle the matter (R.S., Fig. 20).

Treatment.—The **general** treatment for tuberculous cases outlined at p. 194 must be instituted and carried out in as thorough a manner as possible. Every effort must be made to secure sanatorium treatment for these patients; treatment at home is usually very unsatisfactory and liable to be ineffective.

Local treatment is designed to secure the development of a suitable and sufficient synostosis with a minimum degree of deformity, and to this end three essentials must be maintained for a lengthy period, often extending into years—viz., dorsal recumbency, immobilization of the spine, and in case of need, hyper-extension, to prevent or cure deformity (Gauvain). It is obvious that these desiderata can be best obtained in special institutions where treatment is standardized and the means for securing educational advantages, etc., can also be provided; but if this is impossible, the practitioner must use his ingenuity to assist the child and must require the intelligent co-operation of parents and nurses. The actual details of the methods adopted vary enormously in their minutiæ, which it is impossible to discuss here; only general principles can be considered.

Recumbency and *Immobilization* can be secured in many different ways. Thus: (1) The patient is kept in bed lying on his back without a pillow, and with sheets passing over the trunk and thighs, secured by sandbags on either side and between the legs. If thought necessary, extension by weight and pulley may be added, together with counter-extension from above by a weight attached to a chin-strap and occipital band, which are united just above the ears.

For children a weight of three pounds attached to each of these usually suffices to tire the muscles and prevent serious deformity. The child is kept lying down in this way until all sign of active disease has disappeared. In cervical disease the head and neck must also be secured with sandbags, or a plaster bed to include the head and neck may be utilized, or even a box splint for the head with a back-board attached may be employed.

(2) A double Thomas's splint is employed by some, or a Bradford's abduction frame; but in institutions the Berck board and jacket, or some modification of it, are most commonly utilized.

Fig. 360.—Plaster Jacket applied for Tuberculous Caries of Upper Dorsal Spine illustrating Fixation of Head and Neck by a Collar, and Method of Lightening the Jacket by cutting out a Portion. (After Sir H. Gauvain.)

(3) Immobilization in plaster is used by some surgeons from the earliest stage, either in the form of a jacket or a plaster bed. The bed can be used in the case of adults, but is not suitable for children, as immobility is difficult to maintain.

Where a plaster bed is used, the patient is fitted with a vest and turned on to his face. Felt, or dressmaker's wadding, is then placed over the whole back, buttocks, and thighs. Plaster bandages are applied so as to form a mould over the whole back, and reaching round to the flanks and side of the chest, strengthened when necessary by bands of plaster bandage. The mould is then removed and trimmed, the edges being made firm by strips of adhesive plaster. It is allowed to dry, and extra padding with gamgee tissue applied.

Hyper-extension may be secured in any of these various methods without difficulty by the insertion of suitable pads beneath the spine, or by dropping the upper part of the bed in such a manner as will tend to open up the curve. When the deformity has not appeared, or is comparatively slight, there is little risk in this manœuvre, although it must be remembered that in itself it delays healing; but under suitable conditions when the child is being trained and educated, this is not a matter of great importance. But when the deformity is severe and involves a considerable number of vertebræ, the attempt to undo the kyphosis ought only to be under-

taken by specialists who have a trained band of assistants to help them.

After the active disease has come to an end and repair is being established, as indicated by complete disappearance of pain, increasing weight and absence of temperature, as also by radiographic examination, the time has come for considering the question of allowing the patient to walk. This can only be permitted if the spine is satisfactorily supported, and to effect this the application of a *plaster jacket* is perhaps the most satisfactory plan. If the disease exists in the lower dorsal region, the jacket must extend from the axillæ to just below the iliac crests; if situated above the mid-dorsal region, the head also must be immobilized by the formation

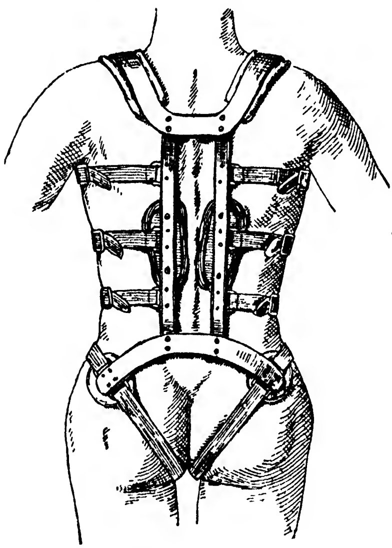


FIG. 361.—TAYLOR'S BRACE (POSTERIOR VIEW).

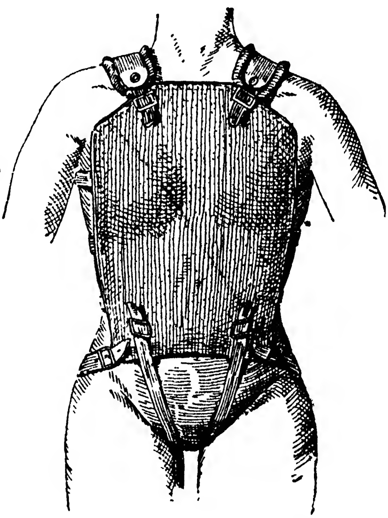


FIG. 362.—TAYLOR'S BRACE (ANTERIOR VIEW), WITH LEATHER APRON APPLIED.

of a plaster collar (Fig. 360). If the disease is in the lumbar region, the jacket may be applied with the patient in the horizontal position; but above this level the patient must be vertical so as to extend the spine. This is best secured by suspending him by means of a bridle attached to the head in a tripod or gallows, and the toes may be allowed to touch the ground. The jacket may be reinforced to meet particular strains, but should always be subsequently lightened by cutting away unnecessary portions—*e.g.*, over the abdomen.

Some authorities prefer to use celluloid jackets instead of plaster, and certainly they are cleaner and more durable. Others employ a brace instead of a jacket in these later stages of the case, and perhaps among the most satisfactory is *Taylor's brace* (Figs. 361, 362).

Should the cervical or cervico-dorsal region be involved, a ring or collar to support or carry the chin in a suitable position of extension, and fixed by a vertical rod to the brace, must be added to the apparatus.

There has been much discussion as to the place and value of *Albee's Operation* in the treatment of tuberculous spines. Not a few surgeons who have had abundant opportunity of seeing it and its results do not recommend it, and amongst these may be mentioned Sir Henry Gauvain; others still practise it. Obviously it is possible by this means to secure immobilization of the affected area of the spine by the introduction of an internal splint, and this should be of value. But it must not be forgotten that the spine, though rigid, is not healed, and that the absorption of the graft or its fracture may lead to subsequent deformity. It is generally agreed that it should never be attempted in children under eighteen years of age, and never in the active stage of the disease; moreover, recumbency for a period of at least six months is almost a necessary part of the after-treatment. Under these circumstances the advantages of the proceeding dwindle considerably, but there are a small number of adult patients in whom it is justifiable and helpful, especially when the lumbar region is involved; these cases are mainly such as demand from a pecuniary standpoint the earliest possible return of the patient to normal habits of life. Of course, plaster jackets or other external supports are subsequently required just as if no operation of this type had been performed. Another method of producing natural ankylosis is by Hibbs's operation, which consists in exposing a number of the spinal processes over the diseased segment, fracturing them, and turning them down so that they interlock. The result is a bar of callus fixing the affected area of the spine.

The **Treatment of Chronic Abscesses** in connection with this disease must be conducted along lines similar to those indicated at p. 197; in other words, they should be recognized and treated at such a stage that opening is unnecessary, and that aspiration should suffice. If need be, aspiration can be repeated more than once, and with care the formation of a sinus should be prevented. Again, we would emphasize the immense gravity associated with the admission of sepsis to conditions such as these, the patient's life being at once placed in the gravest jeopardy.

A *Retropharyngeal Abscess* should always be dealt with from the neck, as described at p. 970.

A *Dorsal, Lumbar*, or *Psoas Abscess* should be aspirated, or tapped with a large aseptic trocar and cannula, and then irrigated and closed without drainage. Occasionally a cure can be obtained in this way by one tapping, but seldom when active disease is present, and only when the patient's general health is good; more commonly the fluid will re-collect, and the same process may need to be repeated two or three times. Sometimes the fluid finds its way along the track of the cannula, and a sinus results, which must be dressed aseptically until

cicatrization has occurred. The best position in which to tap a psoas abscess is at a spot just above and internal to the anterior superior spine; the child is rolled towards the opposite side, and the abdominal contents displaced by gentle manipulation. If a trocar is to be used, a small incision is made through the skin and muscles, so as to make certain of the absence of intestine and large blood-vessels. An abscess should never be left to point below Poupart's ligament, but if such a condition occurs, it may be necessary to deal with it there, perhaps in addition to tapping it in the usual place.

The **Treatment of Paraplegia** arising in the course of Pott's disease consists in maintaining the immobilization of the spine by recumbency, combined with weight extension applied to both legs. At the same time, extra precautions should be adopted in order to prevent bedsores over points of pressure. Should any difficulty in micturition arise, regular catheterism may be required (p. 784).

Laminectomy (p. 794) is very seldom needed at the present day, as few cases fail to respond to the modern helio- and aero-therapeutic methods adopted in sanatoria. The development even of paraplegia does not indicate more than a more efficient and thorough employment of these methods. If, however, paraplegic symptoms come on so rapidly as to suggest the rupture of an abscess without external manifestations, it may be justifiable to explore the cord and relieve pressure. If symptoms persist without improvement for over three months in spite of treatment, exploration is desirable, and relief of the pressure on the cord should be secured. The late appearance of symptoms, characteristic of a fibro-cicatricial development around the cord (peri-pachymeningitis), might also warrant operative interference. Costo-transversectomy has been advocated as a better route for the exposure of abscesses and granulation masses pressing on the cord. This procedure, together with a laminectomy and a bone graft, has been used with success by Girdlestone. It must be emphasized that operations for relief of paraplegia in children are never required under modern conditions of treatment, and in adults the cases are rare.

III. **Syphilitic Disease** is characterized by the development of gummata, commencing beneath the periosteum which covers the bodies; it is of unfrequent occurrence, and gives rise to symptoms somewhat similar to those of tuberculous caries, from which the diagnosis is not always easy, apart from the history and its reaction to treatment. It usually occurs in adults, and is said to affect mainly the cervical vertebræ. Cases have been recorded in which a gumma opened into the pharynx, and portions of bone were discharged therefrom and expectorated. The co-existence of a syphilitic history and of specific lesions elsewhere, together with a positive Wassermann reaction, will determine the nature of the affection.

Treatment consists in the administration of suitable anti-syphilitic drugs, and in the use of a spinal support.

IV. **Rheumatic Spondylitis** is a condition occasionally met with arising from the same causes, and associated with much the same

phenomena as rheumatism elsewhere. It may involve either the ligamentous or muscular tissues, or may attack the intervertebral joints. Any part of the spine is involved, but perhaps the most marked features are presented in the cervical region. Considerable impairment in the movements of the head is then produced, and the neck may be laterally deflected, somewhat simulating torticollis. If untreated, adhesions form between the bones, and the loss of movement may be permanent. Considerable pain of a neuralgic type, due to implication of or pressure upon the nerve-roots, is usually experienced. The **treatment** is of an ordinary anti-rheumatic nature, combined perhaps with the use of a support.

The so-called **Gonorrhœal Rheumatism** also affects the spine occasionally, and brings about much the same results.

V. **Traumatic Spondylitis** is the term applied to a painful condition of the spine which follows injuries, and possibly due to a slight unrecognized displacement or compression-fracture of one of the vertebræ (p. 781). After the period of rest necessitated by the severity of the injury, the patient returns to work, but his back is persistently painful, and after a time some slight deformity of a localized kyphotic or scoliotic type may appear. The reparative changes following on the injury involve a certain degree of congestion of the body of the vertebra, rendering it incapable of sustaining the superincumbent weight of the trunk, and hence it crumples up to some extent, the actual result being governed by the position and severity of the lesion; until the patient is given sufficient rest, the pain will persist and deformity may increase. **Treatment** involves the most careful radiographic examination of the spine and its immobilization by suitable apparatus. A slight displacement of the cervical vertebræ may justify an attempt to reduce it by manipulation under an anæsthetic, or even an open operation to fix the vertebræ by a bone graft of the Albee type (p. 794).

Painful Sacralization of the fifth lumbar vertebra is the term applied to a painful condition of the sacro-iliac region of one or both sides usually attributable to strain. It is primarily due to an elongation and enlargement of the transverse process of the fifth lumbar vertebra which encroaches on, articulates with, or even fuses with the lateral wing of the sacrum or adjacent ilium. Slight lateral flexion of the spine in such a case may pinch the tissues between the bones, or strain the ilio-lumbar or other ligaments, or even compress the anterior root of the fifth lumbar nerve which passes through this interval. The pain produced is of variable type, often simulating sciatica and sometimes renal colic. There is always a tender spot just above the sacro-iliac joint, and the pain and tenderness are both improved by rest. Radiography is a most important adjuvant in diagnosis, so as to ensure the absence of a urinary cause for the pain. **Treatment** consists in rest, the support of a pelvic band and local diathermy; if these fail, manipulation under an anæsthetic frequently gives relief; open operations are usually unsuccessful, although pain may be lessened for a time.

VI. **Spondylitis Deformans** is the term applied to a condition of the spine which results in rigidity and kyphosis. It is seen most frequently in old people, who become bent and shorter than formerly; but it also develops in those who have had to follow laborious occupations, especially in the bending position, and hence is not uncommon in country workhouses and infirmaries amongst those who have had to live and work in the fields or mines. It is akin to osteo-arthritis, and characterized by very similar anatomical changes. The spine is stiff and rigid (hence the name 'poker-back' sometimes applied to it), and this results from absorption of the intervertebral discs, from synostosis of the vertebral bodies, sometimes with the formation and interlocking of osteophytes, and especially from ossification of the spinal ligaments. Pain is often a marked feature of the case, and is then due to irritation of nerve-roots. A large portion of the spine is usually involved, and general kyphosis is the result. Two chief varieties have been described: (*a*) Von Bechterew's variety is one in which the upper cervical and dorsal regions are mainly involved, producing a limited kyphosis, with flattening of the chest and fixation of the ribs. In many of these cases evidences are present of degenerative changes in the posterior columns of the cord and of irritation of the nerve-roots. (*b*) The Strümpell-Marie type, sometimes known as *spondylose rhizomélique*, is characterized by the affection first attacking the lower portion of the spine, but it also involves the hip and shoulder joints. In both forms there is a gradual extension of the process through the whole length of the column, and finally it attacks the articulations between the ribs and the vertebræ; when these become fixed, the respiratory movements are considerably impaired, and hence death is likely to ensue from pulmonary disease. Treatment must follow along the lines laid down for osteo-arthritis.

Tumours of the Spine are usually malignant in character, and most commonly secondary to cancer or sarcoma elsewhere. Simple tumours, such as chondroma, osteoma, and hydatid cysts, occur, as also primary sarcoma. The chief symptoms are severe and localized pain, which is constant, and unrelieved by rest in the recumbent posture, together with early excurvation and paraplegia. Deformity is, however, by no means constant. Neuralgic pain and motor spasms, due to involvement of the nerve-roots, may considerably aggravate the patient's sufferings. These phenomena manifesting themselves in an adult should always suggest the presence of a morbid growth, and the more rapid the onset, the more likely is a diagnosis of malignant disease. Treatment necessarily is but rarely feasible, although an exploratory operation is quite justifiable if the disease is primary and the patient not profoundly cachectic.

Tumours of the Spinal Cord and Membranes develop in several situations, and the symptoms are thereby somewhat modified. (*a*) Outside the spinal dura (extrathecal): lipoma and sarcoma are here most often seen, and the symptoms of cord pressure, such as loss of power and sensation, are preceded by those of spinal irrita-

tion, *e.g.* neuralgic pain increased on movement, and are often limited for some time to one side. Multiple neuro-fibromata of the nerve-roots are by no means uncommon. (*b*) They may grow inside the dura mater (extramedullary intrathecal), and thus produce symptoms of cord pressure and meningeal irritation concurrently. Fibroma, endothelioma, and gumma are the commonest forms of neoplasm in this situation. (*c*) From the spinal cord itself (intramedullary) gliomata and vascular tumours may originate. The symptoms are those of paraplegia combined with some localized and referred pain or tenderness, and either bilateral from the start, or sometimes of the crossed type, anæsthesia being marked on one side of the body, and paralysis and hyperæsthesia on the other, *i.e.* on the side of the tumour. The exact localization of the tumour is of great importance, and assistance can be derived as to its level by the introduction of lipiodol* into the subarachnoid space above the growth. The fluid (1 to 1·5 c.c.) is slowly injected after cisternal puncture. If there is a spinal block, the lipiodol is held up and the level determined by X rays. The introduction of air has also been used, but is not so satisfactory as lipiodol. Although the oil is said to be non-toxic and unirritating, a number of cases of chronic meningitis have been attributed to it, and its use should be limited to those cases in which there is difficulty in accurate localization.

An examination of the cerebro-spinal fluid below the level of the lesion is of the utmost importance in these cases; yellow-coloured fluid (xanthochromine) with a high percentage of albumen and increased globulin is pathognomonic of tumour of the spinal cord. Examination of the pressure of the fluid above and below the lesion is also of great assistance; manometers introduced by cisternal and lumbar punctures should show similar variations in pressure on compression of the jugular veins, coughing, etc.; if, however, there is a spinal block, the variations in pressure will differ (Queckenstedt).

Left to themselves, patients suffering from any of these growths are certain to die, and hence an exploratory laminectomy, with a view to removal of the growth or to the relief of pressure symptoms if practicable, is always indicated when a diagnosis has been effected. The possibility of the disease being syphilitic in origin must not be overlooked, and hence a preliminary thorough course of iodide of potassium and mercury should always be instituted before operating. The operative results of tumours of the spinal cord are good, owing to the high proportion of simple tumours, 40 to 60 per cent. being capable of total removal; and if the case has not been left too long before exploration, there is complete recovery from the paralytic symptoms.

Meningitis serosa circumscripta is a condition characterized by a localized effusion within the meninges, the limitation being due to adhesions of various types which may grasp and constrict the cord, or may drag it aside, and thus interfere with its function. It may

* *Lipiodol* is a colloidal solution of iodine in oil of poppy in the proportion of 0·54 cgrm. of iodine to 1 c.c. of the oil; it is non-toxic and unirritating, and opaque to X rays.

be the consequence of a general infection of the membranes which becomes limited, or the outcome of a localized traumatism. The cerebro-spinal fluid varies much with the completeness of the block, and there does not seem to be any characteristic change. The *symptoms* are those of a compression paraplegia, coming on in a somewhat irregular fashion. It usually affects the lower cervical or upper dorsal region, and is most common in the fifth and sixth decades of life. Subjective sensory rather than motor phenomena manifest themselves in the early stages, but the symptoms vary much and quickly, and the pain is more widespread than in spinal tumours. Motor phenomena become more prominent in the later stages, and especially weakness of the legs, ending in complete paralysis; irritative spasms may also be present, not limited to one root segment. Vesical and rectal troubles do not arise till late in the case. *Treatment* is required either for persistence of symptoms or for spread of the trouble, and consists in laminectomy with free opening of the membranes and removal of the causative adhesions so as to set free the cord.

CHAPTER XXVI.

AFFECTIONS OF THE SCALP AND CRANIUM.

Affections of the Scalp.

Wounds of the scalp are produced either by sharp or blunt instruments, by falls on the head, or by gunshot injuries. From the tension of the scalp over the cranium, it is possible for a blunt weapon, such as a policeman's truncheon, to cause a wound nearly as cleanly cut as if made with a sharp instrument. If the wound is superficial to the occipito-frontalis aponeurosis, but little harm is done; if, however, the layer of loose cellular tissue between the aponeurosis and the pericranium (the 'dangerous area') is opened up and infected, cellulitis (p. 82) is likely to ensue. The vascular supply of the scalp is so good that sloughing is uncommon; a large portion may be torn and bruised, and yet, if it is carefully washed and rendered aseptic, it will probably live. *Complete avulsion* of the scalp usually occurs in women from their hair being caught in machinery. The skin yields just above the ears and supra-orbital ridges, and the aponeurosis is cleanly torn off. Replacement is of course hopeless when separation is complete, and Thiersch-grafting must be relied on for obtaining an epithelial covering.

Treatment.—The hair should be cut away from the neighbourhood of the wound, which is purified in the usual way; the edges may be excised if badly bruised or very dirty. The iodine method of gaining asepsis (p. 294) is particularly useful in these injuries, and may limit the area to be shaved. Stitches should be of a non-absorbent variety, *e.g.*, horsehair. Hæmorrhage from the scalp is often severe, owing to the density of the tissues, which prevents contraction and retraction of the divided vessels. It is sometimes difficult to secure them by ligature, and sutures must then be passed under the vessel so as to control it.

Hæmatoma of the scalp results from injuries that are not associated with solution of continuity of the surface. A similar condition is found in infants, due either to injury of the head during its passage through the mother's pelvis, or to its compression by forceps. Three varieties of cephalhæmatoma have been described, viz.: (*a*) the *Superficial*, which, confined to the dense subcutaneous tissue, is necessarily small. (*b*) The *Subaponeurotic* occupies the

loose tissue under the aponeurosis, and is only limited by its attachments. A large, soft, fluctuating swelling forms, upon which the scalp appears to float, bagging down over the eyes or occiput. It is often due to fracture of the underlying bone. (*c*) The *Subpericranial* is limited by the pericranium dipping down into the sutures around the bone with which it is connected. Most commonly it forms over one of the parietal bones in infants, presenting a soft, fluctuating swelling, which soon gains an indurated margin owing to a deposit of fibrin, and in this condition may simulate a depressed fracture of the skull, inasmuch as the cup-like fluid centre allows the finger to sink in and touch bone below. The indurated margin, however, can be readily indented by the finger, whilst the edge is definitely raised above the surface of the cranium, and hence the sensation of a depression is only apparent. In old-standing cases ossification of the walls of this cavity has even been known to occur. **Treatment.**—All that is required is the application of evaporating lotions. There is hardly ever any need to lay open or drain these swellings unless underlying mischief is present.

Suppuration of the scalp is of common occurrence, arising usually from external infection, but being occasionally due to disease of the subjacent bones. The extent of the abscesses is limited by the same anatomical features as obtain in connection with hæmorrhage. Thus, a *subcutaneous* abscess is necessarily small in size, owing to the density of the tissues in which it is located; it arises most frequently as a result of eczema or impetigo, and is often due to the presence of pediculi, or to the action of irritants used in the cure of ringworm. A *subaponeurotic* abscess usually results from a penetrating wound, and is associated with cellulitis. A *subpericranial* abscess is rarely seen except in connection with injury or disease of the bony calvarium, and is limited to the affected region.

For **Erysipelas** and **Cellulitis** of the scalp, see pp. 136 and 82.

Tumours of the scalp are of many types.

Ordinary *traumatic aneurisms* or *arterio-venous* wounds of the temporal trunk are uncommon; they rarely attain any considerable size, and are readily treated by excision. A curious dilated and tortuous condition of one of the scalp arteries, most often the temporal, is occasionally seen, and is known as an *arterial varix;* it may be treated by complete excision.

Nævi of the scalp do not differ in their characters from those seen elsewhere, except that when situated over the anterior fontanelle they may derive a communicated impulse from the subjacent dura, and so be mistaken for a meningocele.

Cirsoid Aneurism is more frequently met with in the scalp than elsewhere, and chiefly involves the auriculo-temporal region, but may also spread in all directions, even downwards into the neck. In a few cases it has been preceded by a nævus, and sometimes there is a history of injury. A tumour of greater or less size is seen under the skin, consisting of distended, tortuous, pulsating bluish-looking vessels, the arteries opening directly into cavernous

spaces; it is easily emptied by pressure, but quickly refills. The patient often complains of headache and giddiness; the skin becomes thin and atrophic, the hair falls out and finally ulceration may occur, the patient probably dying from hæmorrhage. The **Treatment** is eminently unsatisfactory, complete excision being the ideal cure, but this in bad cases is impracticable. If it be attempted, the incisions should be made wide of the disease, and the supplying vessels secured, if possible, between double ligatures before dividing them; if this precaution is not adopted, frightful hæmorrhage may result. It is necessary in some cases to deal with the tumour in separate segments, allowing time between the operations for the patient to recover from the loss of blood. Probably *diathermy*, combined with ligature of the main nutrient vessels, or of both external carotids, holds out the best chance of success.

Papillomata are not uncommon in the form of small hard warty outgrowths, giving rise to but little inconvenience, unless situated on some spot where the hat rests. They are easily removed.

Lipomata also occur, and are usually situated in front, arising from the deeper layers of the scalp or from the pericranium. They generally expand laterally and are flattened. Removal is readily effected.

Epithelioma also occurs, arising either from an irritated papilloma, or possibly in connection with a sebaceous cyst. As soon as a diagnosis is made, the growth should, if possible, be extirpated, and the resulting raw surface may be either left to granulate, or dealt with by Thiersch's method of skin-grafting.

Neuro-fibromatous growths sometimes involve the scalp, giving rise to irregular nodulated masses of soft tissue which may even hang around the root of the neck in large coils; it is then known as a **pachydermatocele** (p. 221). Excision is the treatment if the mass is not too large.

Sarcoma of the scalp is uncommon apart from a similar affection of the underlying bones. It develops as a large fleshy tumour which may pulsate or fungate, and usually grows rapidly, but is limited for some time by the aponeurosis of the occipito-frontalis. Treatment by a wide excision and Thiersch-grafting may be possible, but if the condition is at all advanced the only hope lies in the use of radium or the X rays.

Dermoid Cysts are by no means uncommon in this region, their favourite situation being near the outer canthus, the temple, or the root of the nose. For a general description, see p. 245. They do not attain any great size, and may not become evident till after puberty. The underlying bone is often hollowed out from a defective development of the mesoblastic tissues around them, and a congenital opening may even exist through which a narrow neck passes, bringing the cyst into direct connection with the dura mater. The *treatment* consists in removal; but it is advisable to delay this till after puberty if the tumour seems at all fixed to the skull, or if the bone is felt to be defective beneath it, as in such cases the communication with the interior of the cranium is often shut off by that time.

Sebaceous Cysts (p. 453) find their most usual situation in the

scalp, where they are frequently multiple. Their removal is best accomplished by transfixion, squeezing out the contents, and picking out the cyst wall by a pair of forceps without dissection. The wound is closed by one or two stitches.

Sebaceous Adenoma is most frequently seen on the scalp (p. 454).

Affections of the Cranium.

I. **Congenital Affections.**

1. In babies the ossification of the bones may be incomplete, constituting what is known as *aplasia cranii congenita*, and is due to a cachectic condition of the mother. Occasionally a similar atrophic condition of the bones may persist through life, exposing the patient to increased risk from injuries which otherwise would do but little harm.

2. **Meningocele, Encephalocele,** and **Hydrencephalocele** consist of a protrusion of the dura mater, with or without part of the brain,

FIG. 363.—MENINGOCELE OF THE FRONTAL REGION.

through an opening in the cranial wall. They are due to defective intrusion of the mesoblastic tissues outside the primitive cerebral vesicle, so that part of the brain or its membranes remains superficial and extracranial. They occur most frequently at the root of the nose, and in the occipital region (Fig. 363), occasionally at the anterior or lateral fontanelle, or at the base of the skull. A *Meningocele* is simply a protrusion of the brain membranes containing cerebrospinal fluid. It forms a soft, rounded, fluctuating swelling, attached to the skull by a base of greater or less size, and covered by skin, which may be thick and healthy, or thinned, bluish, and translucent when the tumour is large. The vessels present in the skin are often dilated and nævoid. It increases in size and tension on any expiratory effort, such as coughing or crying, and it may be partially reducible, thus allowing the margins of the opening in the cranium to be defined. Symptoms of cerebral compression, convulsions, etc., are likely to be produced by such manipulation. An *Encephalocele* is a similar type of tumour, but contains brain substance, and pulsates almost synchronously with the heart; it is most commonly

situated at the back of the skull. A *Hydrencephalocele*, or Meningo-encephalocele, is a condition in which the tumour contains both brain substance and fluid. Two varieties have been described—one in which there is a small protrusion of the brain associated with an ordinary meningocele, and the other in which the fluid is contained in a cavity communicating with one of the ventricles, and covered by a thin layer of brain substance. They are usually of considerable size, and situated in the occipital region, either above the tentorium, and then possibly associated with distension of the posterior cornu of one of the lateral ventricles, or below that structure, the osseous defect extending in some cases as far as the foramen magnum, and a portion of the cerebellum being within the sac.

The **Prognosis** of these conditions is exceedingly grave. Fortunately, many of the subjects are born dead, or die soon after birth. In the more severe cases, idiocy and microcephaly are not uncommon, whilst sometimes hydrocephalus is present. The protrusion may increase steadily in size and finally burst, causing death by meningitis, or in more favourable cases it may remain stationary. In a meningocele, the subsequent growth of the bones may suffice to close the communication between the interior and the tumour, which thus becomes shut off, and remains as a cyst-like swelling, with the base fixed, and without pulsation or respiratory impulse.

Treatment.—Most cases should be left alone; but if the swelling is increasing, aseptic puncture and subsequent compression may hinder the process. A simple meningocele may possibly be cured in this way, but when the communication with the skull is small, it is often feasible to open the sac and suture the base securely, making good the cranial deficiency by osteoplasty.

II. **Acquired Affections** of the skull are atrophic, hypertrophic, inflammatory, or neoplastic in nature.

Acquired Atrophy of the skull occurs in many forms:

(*a*) *Craniotabes* is a condition met with during the first year of life, usually as a result of inherited syphilis (p. 660).

(*b*) *Senile* atrophy may affect the whole cranium, which becomes thinned and rarefied; or it may be localized, *e.g.*, to the parietal bones, constituting hollow depressions which extend antero-posteriorly.

(*c*) Localized loss of substance may result from the pressure of tumours, such as Pacchionian bodies and aneurisms, from necrosis, or from traumatic and operative lesions. If these are at all extensive, the cerebral pulsations can be felt distinctly through the skin. It is then advisable to provide the patient with some guard to protect him from injury. This may be accomplished by means of a metal plate worn over the scalp; but in favourable cases some form of cranioplasty should be adopted (p. 841).

(*d*) *Essential Hydrocephalus* is always associated with atrophy and thinning of the cranium; it may be congenital, or may commence early in life. It is produced in almost all cases by a distension of the lateral ventricles with fluid, the result of congenital malforma-

tion or of inflammatory affections of the base of the brain. Thereby the secretion of the cerebro-spinal fluid by the choroid plexuses may be increased beyond the functional capacity of the channels of exit (p. 843); or the escape of the fluid from the ventricles may be prevented by pressure or obstruction; or, finally, the communications with the venous sinuses may be blocked, in which case there is some excess of fluid outside the brain as well as within it. A high-grade hydrocephalus can be produced by injecting lampblack into the cisterna magna, thereby choking the openings into the venous sinuses. The head becomes more and more distended (Fig. 364), the bones are expanded and thinned, and the sutural areas increased, whilst the brain is subjected to such pressure as

FIG. 364.—HYDROCEPHALUS

The greatly enlarged cranium, the overhanging eyebrows, the staring eyes, the wasted features, and the attenuated body constitute a typical picture.

may be incompatible with life. Fluctuation is distinctly felt, and the bones may crackle under the fingers; the face looks abnormally small, and the eyes protrude, owing to the depression of the orbital plates. *Treatment.*—Tapping of the ventricles is useless, as even if a considerable amount of the fluid is withdrawn, and elastic pressure subsequently maintained, recurrence is almost inevitable. The only hope is to establish a free communication between the ventricular and subdural spaces, so that the excess of fluid in the ventricles may escape; it will be absorbed from the subdural space as soon as the tension rises above the intravenous pressure. A silver tube should be inserted between the two spaces, or a tube of decalcified bone carrying a catgut drain; to be of any value, the

operation must be undertaken before the cerebral cortex has been so thinned as to interfere with its functional activity.

(e) By *Microcephaly* is meant a condition of diminished size of the cranial cavity due to premature ossification of the sutures, and resulting from non-development of the brain. It is usually associated with idiocy, and possibly with cretinism. Attempts have been made to relieve this by the operation of linear craniectomy or removal of portions of the cranium, so as to allow of the expansion of the brain. Temporary improvement has followed in a few cases, probably from the individual attention given to the patient; the final result is extremely uncertain, most of the patients relapsing owing to the contraction of the dense cicatricial material which replaces the bone, and to the atrophic condition of the brain.

Hypertrophic Changes of the Skull result from simple chronic inflammatory affections, or from injury, etc. Special types of enlargement are seen in inherited syphilis (p. 659), rickets (p. 661), osteitis deformans (p. 667), and acromegaly (p. 669). In leontiasis ossea (p. 903) the cranium becomes thickened and enlarged; but the cranial cavity is also encroached on, constituting what is known as *concentric* hypertrophy, in contrast to most of the other forms, which are *eccentric* in type.

Inflammatory Affections of the Cranial Bones.—The cranium is liable to any of the diseases which generally occur in bone.

1. **Acute Periostitis, or Pericranitis,** is usually infective in origin, following cellulitis of the scalp; it is likely to result in necrosis of the outer table.

2. **Acute Infective Osteomyelitis,** or acute necrosis, consists of an acute inflammation of the diploe, due to pyogenic organisms, and either following an infected scalp wound or compound fracture, infective inflammation of one of the air-sinuses (especially the frontal sinus or mastoid antrum), or the operation necessary for its treatment, or a simple contusion of the bone in a person of low germicidal powers; it may also be pyæmic in origin. The symptoms and signs are those generally characteristic of the disease, being ushered in by a rigor, followed by headache, fever, and the development of a localized œdematous swelling, known as 'Pott's puffy tumour' (Fig. 375). The pericranium is stripped up by diffuse suppuration beneath it, and an abscess often forms between the bone and the dura mater. Necrosis of the whole thickness of the skull is likely to follow, but is usually limited by the sutures to the particular bone affected. Pyæmia and extension of the inflammation to the membranes, venous sinuses or brain, are the chief dangers arising from it. The prognosis is always grave, even when early operative treatment is undertaken; apart from operation, it is almost hopeless. The *Treatment* consists in free external drainage, together with the removal of the outer table in early cases to enable the infected diploe to be curetted. If signs of subcranial suppuration ensue (p. 864), the inner table must also be widely taken away. In the later stages, necrosed bone is removed when it has been set free.

3. **Chronic Periostitis** is occasionally met with in the form of a node. If independent of syphilis, it is usually the result of long-continued irritation, such as carrying baskets or weights on the head. *Treatment* consists in the discontinuance of the causative irritation, and there is no objection to chiselling away the node, if necessary.

4. **Tuberculous Disease** of the cranial bones is not common; it occurs as a primary phenomenon, or more commonly is secondary to a meningeal focus. It may start in the periosteum or diploe, leading to the formation of a node, or perhaps to expansion of the bone, and followed by suppuration and caries. When of meningeal origin, there is a considerable amount of erosion of the inner table, and possibly some necrosis; sooner or later the outer table is perforated and a subpericranial abscess forms. The amount of mischief in the outer table is no criterion of the extent of the disease within, and hence a thorough exploration is necessary. The prognosis in this variety is not good, unless active operative measures are taken at an early date, combined with suitable constitutional treatment. The mastoid process and the orbital margin in the neighbourhood of the external angular process of the frontal bone are rather favourite situations for the disease.

5. **Syphilitic Disease** used to be exceedingly common, but is now seldom seen. It occurred usually in the tertiary stage, and affected most frequently the frontal and parietal bones. It has been already described (p. 658).

Tumours of the Cranial Bones.—The chief **Tumours** affecting the calvarium are osteomata and sarcomata.

Osteoma of the cranium (Fig. 56) occurs as a localized overgrowth of compact bone from the outer surface of the calvarium, from the inner, or from both. The frontal bone and external auditory meatus are the sites of election. If arising externally, a smooth, rounded, globular swelling is produced, hard to the touch, quite painless, and fixed to the subjacent bone by a broad base; more than one may be present. If the main growth is internal, symptoms of cerebral irritation or pressure are produced. Osteomata are to be distinguished from inflammatory hyperostoses (usually of syphilitic origin) by their sharp limitation, absence of pain, and slower progress; whilst osteo-sarcomata are commonly rapid in growth, painful, and of unequal consistency in different parts. **Treatment** is rarely necessary. Small growths may be encircled in the crown of a trephine and thus removed. Large ones must be dealt with by an electric saw or burr, the bone being divided just outside the dense compact tissue, and thus the tumour is set free. No attempt should be made to chisel away those growths, as symptoms of concussion may follow the prolonged use of the chisel and mallet against the skull. The defect in the bone is subsequently made good by cranioplasty (p. 841).

Sarcoma of the cranium originates from either the pericranium, the diploë, or the dura mater.

The *pericranial* variety consists of a round or spindle-celled tumour growing from the pericranium, and possibly attaining a considerable size. It may contain a certain amount of ossific deposit, or the tumour remains of a soft consistency, and then often pulsates. The subjacent bone is sometimes absorbed, and the dura mater affected secondarily. General infection of the system follows.

Central Sarcoma commences in the diploe and spreads both outwardly and inwards. In this situation, however, a *myeloma* may develop, and simulates a sarcoma; its growth, however, is slower and it is covered with a thin layer of bone, which may crackle beneath the fingers. It is commonly secondary to sarcoma of the kidney.

Secondary Carcinoma of the cranial bones is by no means uncommon, and may follow cancers of the mamma, thyroid body, etc. The growths are usually small and multiple, and may show pulsation. Neuralgia and persistent headache result from them.

III. Traumatic Affections of the Cranium.

Contusions of the Cranial Bones apart from fracture may lead to serious results. 1. Many of the inflammatory conditions of bone just described may be originated; *e.g.*, if the patient is in a condition of low germicidal power, acute osteomyelitis may follow; or chronic sclerosis and overgrowth of the bone, local or diffuse, may supervene. Syphilitic or tuberculous manifestations may be similarly lighted up if the patient is the subject of either of these diseases. 2. In addition to such osseous conditions, pus may form within the cranium outside the dura mater (*subcranial abscess*, p. 864), and necessitate operation. 3. The dura mater may be detached by a simple contusion, leading to meningeal hæmorrhage (p. 860). 4. Any of the cerebral lesions detailed hereafter may be produced. Contusions of the cranium must obviously never be treated lightly, even when they are associated with unbroken skin; much more are they serious when open, owing to the risks of infection.

Fractures of the Skull may be described for convenience under the following headings: *Fissured Fractures of the Vault; Fractures of the Base* (usually fissured); and *Depressed or Punctured Fractures.*

1. **Fissured Fractures of the Vault** are always due to external violence, direct or indirect. In the former case the skull first yields at the injured spot, but the fissure may extend from it for some distance; in the latter the fracture results from the yielding of the skull when compressed beyond its natural limits of elasticity (R.S., Fig. 18).

A closed or simple fissure gives rise to no symptoms indicating its presence with certainty. There may be some amount of superficial ecchymosis and tenderness, but nothing more definite. When open, the line of fracture may be seen as a red streak, or even felt with the finger as an irregular ridge. It consists of a single longitudinal fissure, or may be starred; if uncomplicated, it is of but little import-

ance, and needs nothing beyond general treatment and the maintenance of asepsis. Occasionally, however, a mass of protuberant callus forms on the inner aspect of the cranium at the site of fracture, or the dura mater becomes thickened by organization of effused blood; either of these lesions may give rise to chronic headache or discomfort, or even to traumatic epilepsy or insanity (p. 881).

Traumatic Cephal-hydrocele is the name given to a rare condition following simple fractures of the vault, especially in children. It is characterized by the formation of a fluid swelling under the scalp, which pulsates synchronously with the heart-beat, and has a definite impulse on any expiratory effort; it varies in size from time to time and is sometimes partially reducible. It contains cerebro-spinal fluid, and communicates with either one of the lateral ventricles or the subarachnoid cavity. In one case it was proved on operation to be connected with an arachnoid cyst, due to a localized subarachnoid hæmorrhage. Probably it is wise to leave this condition alone, unless one is tolerably certain that the ventricle has not been affected, and then it may be incised.

2. **Fractures of the Base of the Skull** are almost always fissured, and only occasionally punctured or depressed.

Causes.—(*a*) *Violence may be directed to the vertex or to some part of the cranial convexity,* as from a blow or fall upon a hard substance. There has been a good deal of discussion as to how a fall on the vertex causes fracture of the base. Two main theories hold the field, each being probably responsible for a certain number of cases. (i.) Aran's theory of irradiation maintains that a fracture of the base is always due to direct extension of the fissure from the injured vertex, a proposition probably quite true in many cases, but insufficient to explain all. (ii.) A more recent idea, known as the *bursting or compression theory,* is based on the fact that the cranium is not a solid and totally unimpressionable body, but is highly elastic, as has been proved by the observation that hair and even pieces of skin have been found nipped in a fissured fracture of the vault, which had evidently gaped open and closed again. Moreover, it is very irregular in shape and of very variable strength and density, and the base is weakened by the presence of numerous foramina for the passage of spinal cord, vessels, and nerves; the base is also less elastic than the vault. Severe compression necessarily diminishes the diameter of the skull along the axis of greatest pressure, making it bulge in other diameters; if this exceeds the limits of elasticity of the bone, a fracture must result. Most commonly the lines of fracture are parallel to the direction of the compressing force, the bone thus bursting open along its convexity (fracture by bursting); less frequently it gives way at right angles to the direction of the force (fracture by compression). Inasmuch as the force is transmitted equally in all directions, the weakest and least elastic part is always most likely to give way, viz., the base. (*b*) *Direct or indirect injury* to the base of the skull is undoubtedly the cause of a certain number of fractures, and some of these are depressed, and not fissured, in character. Thus, the point of an

umbrella or a stick may be thrust through the upper wall of the orbit, or up the nose through the cribriform plate of the ethmoid; the condyle of the jaw may be driven through the glenoid cavity into the middle fossa by a blow on the chin; direct injury from a fall or a stab may penetrate the occipital bone; whilst a gunshot wound in the mouth is another illustration of this kind of injury. (*c*) The *impact or resistance of the vertebral column against the occipital condyles* produces fractures in the posterior fossa which radiate from the foramen magnum, and may even occasion a ring-shaped fracture around it (Fig. 365). They result from falling on the vertex into a soft mass—*e.g.*, a bale of wool—or by alighting from a height on the heels or nates.

The fracture may run in any *direction*, longitudinal, oblique, transverse, etc., according to the direction of the compressing or fracturing

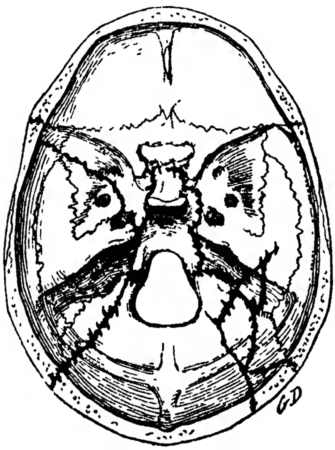


FIG. 365.—FRACTURE OF THE BASE OF THE SKULL FROM FORCE ACTING AGAINST THE OCCIPITAL CONDYLES.

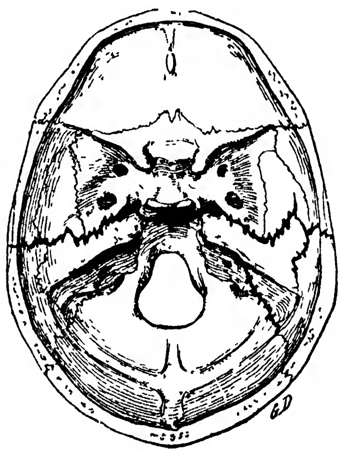


FIG. 366.—TRANSVERSE FRACTURE ACROSS THE BASE OF THE SKULL.

force, and it may affect any part of the base, either being limited to one of the fossæ or involving all; it may follow the sutural lines in part, but it is no uncommon thing to see even the dense petrous bone traversed by a fissure (Fig. 366). Naturally, transverse fractures are more likely to be limited to one of the fossæ, whilst a longitudinal fissure may involve them all.

Some fractures of the base of the skull are closed in nature, but the majority are *open*. In the anterior fossa the fissure extends through the cribriform plate and nasal mucosa, and then lays open the nose; or a communication may be established with the external air through a penetrating wound in the orbit, or through the ethmoidal or sphenoidal sinuses. In the middle fossa a fracture through the base of the sphenoid opens the roof of the naso-pharynx, or the fracture may involve the tympanic cavity. In the posterior

fossa the basi-occipital may be broken, and again the naso-pharynx opened, although the fracture here is more commonly closed.

Fractures of the base of the skull, though very serious, are by no means necessarily fatal, and since the introduction of antiseptic methods the results have immensely improved. The main *dangers* to be apprehended are: (i.) Damage to the base of the brain, including the pons and medulla, especially in cases where the foramen magnum is splintered from the impact of the spine against the condyles; (ii.) hæmorrhage arising either from the venous sinuses, or from the meningeal or cerebral arteries; and (iii.) infective meningitis, due to the fact that the injury not only fractures the bones, but also tears the dura mater, a grave addition to an open fracture.

The **Signs** of a fractured base are sometimes exceedingly equivocal, but for convenience may be arranged under four heads:

(1) *Signs of severe cerebral mischief* such as concussion of the brain and prolonged unconsciousness. This is, however, by no means always present; thus, in a case we had in hospital some years back, the patient was capable of going about his work for ten days after the accident.

(2) *Hæmorrhage* manifests itself in various directions, according to the situation of the fracture.

In the *anterior fossa* there may be free bleeding from the nose, owing to the fracture extending through the cribriform plate of the ethmoid; but a portion of the blood may pass backwards into the pharynx, and, being swallowed, is perhaps subsequently vomited. More often, however, the line of fracture runs across the roof of the orbit, causing escape of blood into the areolar tissue of this cavity. The ecchymosis shows itself as a gradually developing subcutaneous distension, involving the lower lid, bluish-purple in colour at first, but passing later through the other stages of a bruise; there is probably no contusion of the skin, as in the ordinary black eye, which is at first reddish-purple; the ocular conjunctiva is considerably involved, but the effusion rarely extends above the cornea, and its posterior limits cannot be seen. The bleeding usually arises from laceration of the dura mater and bone, but, when abundant, may come from the cavernous sinus, and the eye may even be pushed forwards (proptosis); in some cases pulsation is to be felt within the orbit, and then a traumatic orbital aneurism or aneurismal varix is present.

In the *middle fossa* the blood may enter the nose or mouth, a part being swallowed, but more commonly it escapes from the ears. Examination of the naso-pharynx and ear should always be made in serious head injuries, and if practicable by a specialist. It may be possible to see blood trickling in a thin stream from the Eustachian tube when there is no external evidence of bleeding; or the blood may collect in the tympanic antrum and be seen through an intact membrane as a dark bluish-black collection. If the bleeding is abundant, it probably comes from one of the vascular channels at the base of the skull; but if only slight in amount and of short duration, it may be induced by any of the following lesions, as well as by a

fractured base; viz.: (*a*) A simple rupture of the membrana tympani; (*b*) separation of the cartilage of the pinna, with tearing of the lining of the external meatus; (*c*) fracture of the anterior and lower part of the tympanic plate, as by a blow on the jaw, which drives the condyle forcibly against it.

In the *posterior fossa* the bleeding is usually subcutaneous, showing itself around the mastoid process, and extending downwards amongst the muscles at the back of the neck.

(3) *Discharge of cerebro-spinal fluid* (p. 843) is an indication that a communication exists with the subdural space. The fluid may be discharged from one or both ears, but has also been met with coming from the nose or cranial vault; when from the ear, the dura mater has probably been laid open through the prolongation which accompanies the auditory nerve in the internal meatus by a fracture traversing the petrous bone. At first it is probably blood-stained, but soon becomes quite clear. The amount discharged may be small, but not unfrequently it comes away in large quantities, soaking the pillow and dressings, and, indeed, can sometimes be caught in a test-tube as it trickles from the meatus. As a rule, the flow commences soon after the injury, and quickly ceases; but some years back a curious case occurred, under the care of Lord Lister at King's College Hospital, of a man who had fallen backwards off a high bed upon his occiput; he was temporarily stunned, but returned to bed, and, on awaking the next morning, found that both lower eyelids were black. He continued work for ten days, complaining, however, of headache, and at the end of that time of earache, which grew steadily worse, until relieved by something giving way in his left ear. This was followed by a copious discharge of cerebro-spinal fluid, which was maintained for some time, and from the after-history there can be no doubt that it was due to a fractured base. Evidently the fluid which had leaked into the internal ear through the line of fracture had escaped down the Eustachian tube for a time. For some reason this became blocked, giving rise to tension, which was finally relieved by the rupture of the membrana tympani.

(4) Escape of brain substance from the ear has also occurred in a few instances, most of them fatal.

(5) *Lesions of the nerves* issuing from the base of the skull are occasionally produced. For symptoms, etc., see Chapter XVI. The nerve most commonly involved is the facial, as it passes through the aqueductus Fallopii; the paralysis may develop either immediately, or more often about the second or third week after the injury, disappearing in about a month, and then evidently due to its implication in the callus (p. 424). A certain amount of deafness is often associated with it from injury to the auditory nerve. Fractures through the anterior fossa are often followed by loss of smell from injury to the olfactory nerves.

The **Prognosis** of a fractured base has much improved during recent years, as a result of the application of antiseptics to the auditory meatus. If the patient escapes death from acute cerebral complica-

tions, the bones of the skull unite rapidly, and a good result may be expected, although troublesome sequelæ may follow from the development of various types of late cerebral mischief, or from the injury sustained by nerves or vessels, or from their compression in callus or new bone.

Treatment.—Seeing that the chief danger to the patient arises from infection of the meninges, the greatest care must be directed towards preventing the access of bacteria. Unfortunately, it is impossible to apply dressings to the naso-pharynx, or even to wash it out thoroughly with antiseptics, and the only satisfaction about such cases is that the rareness of the loss of the cerebro-spinal fluid suggests that the membranes of the brain are not very often damaged in that situation, whilst it has also been shown that in the majority of cases the upper part of the nasal cavity is aseptic (St. Clair Thomson). With the ear, however, things are very different. The pinna should be thoroughly cleansed, and the meatus, if no previous otorrhœa existed, should be gently but thoroughly irrigated with warm 1 in 20 carbolic lotion, or filled with 2½ per cent. tincture of iodine, any cerumen being taken away with forceps if possible. A large pad of sterilized gauze and wool should be bandaged over the ear and head, and replaced as often as necessary. The presence of chronic otorrhœa is obviously a serious complication, and may determine grave septic infection of the meninges. Opinions differ somewhat as to treatment under these circumstances. Some say that all such cases demand an immediate complete mastoid operation so as to protect the lesion in the base of the skull. Others, probably with justice, suggest that such a procedure may light up infection by interference, and counsel watchful delay, only opening up the mastoid process should symptoms suggest its necessity. It must not be forgotten that the escape of cerebro-spinal fluid through the ear is likely to wash infective material outwards and not inwards.

Beyond this, the treatment of fractured base is directed to the cerebral condition, and does not differ from that usually applied to head injuries, viz., cold to the shaved head, a smart calomel purge to start with, low diet, and absolute quiet in a dark room. In the absence of signs of cerebral irritation or inflammation (viz., increased rapidity of pulse, persistent headache, giddiness, etc.), the patient may be allowed to sit up in bed at the end of a week, and his diet is gradually increased; but he should not be permitted to get out of bed for a fortnight, and even then must keep very quiet, and not think of returning to work for four or six weeks.

For the later management of head cases, see p. 858.

3. **Depressed or Punctured Fractures** usually involve the vault of the cranium, and are due to direct violence, either from a fall or blow, causing a closed or open fracture, or from a penetrating injury occasioning a punctured fracture. In both cases there is often a considerable amount of comminution.

It is quite possible for the outer table to be broken and depressed without any injury to the inner, where an air cavity exists in the bone, or if the diploe is very thick; thus, the bone may be driven in over the frontal sinus without injury to its inner wall, or the mastoid may be similarly affected. The inner table has also been broken, and fragments even separated, as a result of a simple depression without fracture of the outer table; this rarely occurs in adults, but is not uncommon in children. Amongst the latter, it is also possible for a considerable depression to exist without any fracture of the inner table.

More usually both inner and outer tables are involved, and when this is due to force reaching it from without, the inner table is always more damaged than the outer, especially in the punctured variety (Fig. 367, A and B). When, however, the force is applied from within, as by a bullet which has traversed the brain, the outer table suffers more than the inner. The causes of this condition are similar from whichever side the force comes, but need only be considered when the violence acts from without. (*a*) The inner table is less supported than the outer, having merely the soft brain and dura mater within, and hence is extensively splintered, just as a nail driven through an unsupported piece of wood causes ripping up of its under surface. (*b*) The loss of momentum of the fracturing body will assist this; the greater the momentum of a penetrating body, the more cleanly it cuts, a smaller momentum breaking or splintering rather than cutting; of course, a considerable amount of force is expended in penetrating the outer table. (*c*) The débris caused by the injury to the outer table will add to the bulk of the penetrating body, and its wedge-like action still further increases the injury to the inner table. (*d*) All force tends to radiate and diffuse itself from the spot struck, and hence, if the outer table is first injured, the force will be disseminated over a more extensive area of the inner.

The **Symptoms** and **Signs** arising from a depressed fracture vary widely in their nature, and are partly due to the injury inflicted on the bone, partly to that sustained by the brain, whilst the infection or not of the wound is of the gravest significance.

Locally, when an external wound is present, one sees blood or cerebro-spinal fluid escaping, or even brain substance protruding. The damage to the bone may be seen or felt, and the extent of the depression or comminution thus ascertained. When there is no external wound, a hæmatoma of variable size forms under the scalp, more or less obscuring the fracture. The character of the lesion is a matter of considerable importance from a prognostic point of view. When the bone shelves evenly in all directions, a *pond* or *saucer* fracture is said to be present, and this is tolerably amenable to treatment; when, however, the depression is sudden and complete, the detached portion lying below the level of the rest of the bone, it is termed a *gutter* fracture, and the prognosis is increasingly grave. The two forms are, however, often associated. Necessarily, con-

siderable variations are met with in this type of fracture, according to the nature of the injury and the means by which it was inflicted. Thus, if it is due to a fall on the vertex, there is often a ragged, irregular scalp wound, through which the depression can be seen or felt; if caused by the puncture of a sharp tool, such as a pickaxe, there is only a small external opening corresponding to the hole in the skull, in which the point of the instrument may be found embedded. A slicing cut with a sabre or hatchet produces a clean incision through the scalp, together with a linear groove in the skull, perhaps somewhat bevelled, which may or may not penetrate its whole thickness. Sometimes detached portions of the skull are raised above their ordinary level, constituting an *elevated* fracture; it is usually associated with depression of surrounding parts.

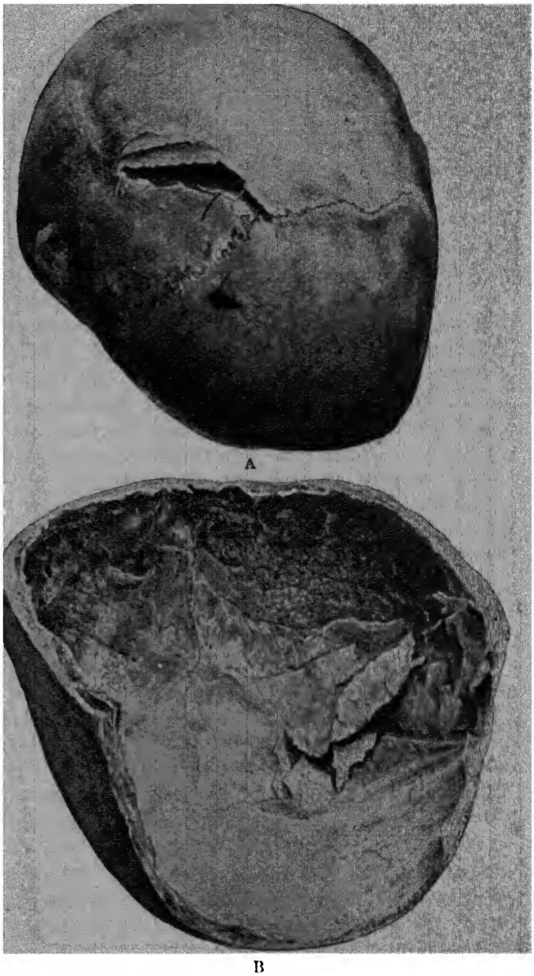


FIG. 367.—DEPRESSED FRACTURE OF SKULL SEEN FROM WITHOUT AND FROM WITHIN. (KING'S COLLEGE HOSPITAL MUSEUM.)

In a *closed depressed fracture* the patient usually suffers from concussion, followed almost immediately by compression, the latter due in part to the depressed bone, but mainly to exudation of blood and bruising of the brain; if this is at all extensive and remains unrelieved, a fatal result quickly follows. Where, however, the depression is but slight, the symptoms of compression may be absent or not marked, and the patient recovers, perhaps to become the

subject of chronic headache, traumatic epilepsy or insanity at a later date, induced by the irritation of the dura mater and of the subjacent cortex. If the depressed fragments irritate the motor area, convulsions, spasms, or paralysis may be thereby induced.

In an *open depressed or punctured fracture* the immediate effects are not necessarily severe, the patient perhaps not even suffering from concussion, though brain substance presents in the wound; the more limited the spot injured, the less the concussion. The explanation of this fact is that the blow has expended its force in fracturing the cranium, and hence does little harm to the brain, in the same way that a watch may receive but slight damage from a fall if the glass is broken, whilst if the latter remains intact the works are liable to suffer.

Left to itself, such a fracture is sure to become *infected*, and inflammation of the bone, brain, or membranes will follow.

Septic osteitis leads to necrosis of the fragments, which may be seen lying dead and yellow at the bottom of the wound, whilst the inflammation may either spread along the diploe to the surrounding bone, causing extensive necrosis with pyæmia, or between the bone and the dura mater, leading to a subcranial abscess.

When once the dura mater has been penetrated, inflammation is liable to spread to the meninges, and then a diffuse or localized suppurative meningitis, accompanied or not with a localized suppuration of the brain, will ensue. Even if the dura mater has not been opened by the injury, the irritation of depressed spicules of bone and the presence of a purulent exudation often lead to its ulceration at a later date. If there is a free external opening, allowing a ready exit to the discharge, and thus preventing tension, the process may be quite limited, and compression of the brain or diffuse septic meningitis is avoided; but if the fragments of bone are locked together as well as depressed, and the external wound is small, retention of inflammatory products may lead to their diffusion, and the symptoms of compression will soon become evident. A hernia cerebri may also form subsequently.

When the fragments of depressed bone are early removed, even if perfect asepsis is not attained, the patient has a good chance of recovery; whilst laceration of the dura need not result in meningitis, since the opening in the subdural space can be shut off by adhesions of the arachnoid in a very short time.

When an *aseptic* condition of the wound is obtained by early interference, and depressed fragments of bone are successfully elevated or removed, the prognosis becomes much better, and the case may run an uncomplicated course towards recovery, unless some deeper cerebral lesion co-exists.

The **Treatment** of these cases is based on the belief that a patient runs greater risks from leaving a slight depression unrelieved than by making even what may prove to be an unnecessary exploration. The object of the operation is to protect the dura mater, if uninjured, from the irritation of the sharp edges of depressed fragments; to

free the brain from the pressure of the depressed bone or of effused blood; and if the dura mater is torn, to remove hopelessly damaged brain substance, or protect it as far as possible from the risks of infection, or to provide free drainage if infection is already present.

The indications for operation may be epitomized thus:

(i.) In all punctured fractures, operate.
(ii.) In all open depressed fractures, operate.
(iii.) In closed depressed fractures: In adults, always operate; in children, if gutter-shaped, operate; if pond-shaped, wait for symptoms, unless the fracture is a bad one.

The most debatable of these propositions is that relating to the closed depressed fracture in an adult. It may be objected that many such cases have recovered without operation, and that therefore in shallow depressions one should wait for symptoms; but whilst the existence of such cases must be admitted, the fact remains that serious after-effects are not uncommon sequelæ of a slight unrelieved depression. The operation in itself is simple, and the risk insignificant when asepsis is maintained, so that one cannot but insist that the patient should be given the benefit of an exploration, especially since one can never be certain of the amount of injury sustained by the inner table. At the same time it must be remembered that elevation of the depressed bone may not relieve the symptoms, as they may be due to a hæmorrhagic effusion in the brain which cannot be remedied.

When an operation has once been decided on, the sooner it is undertaken the better. The scalp should be shaved and thoroughly purified. An anæsthetic may or may not be given, according to the condition of the patient; if he is comatose, he requires no anæsthetic; if he is partially sensible, local infiltration anæsthesia should be employed, or gas and oxygen; chloroform is especially undesirable. In a *closed depressed fracture* a flap of scalp is turned down so as to avoid the presence of a cicatrix over the lesion in the bone. Having cleared away blood-clot and exposed the fracture, some loose fragments may be exposed, and the removal of these may permit of the introduction of an elevator; if more room is required, a de Vilbiss forceps or a rongeur will suffice to enlarge the opening. If there are no loose fragments, it is sometimes possible to make an opening by sawing off a corner of bone with Hey's saw. If neither of these plans is feasible, an opening must be made with a trephine. The centre-pin is placed upon some firm undepressed bone as near the margin as possible (Fig. 368), and a circle of bone removed. An elevator can now be introduced, the fragments prised up into position, and the condition of the inner table investigated. Care must be taken in removing loose fragments not to tear the dura mater by injudicious violence; especially is this the case when the fracture lies over one of the venous sinuses. Sufficient bone must be taken away to allow the whole of the damaged area to be examined.

If the dura mater has been injured, brain substance mixed with

blood may escape as soon as the flap is raised. When the bone has been dealt with, any protruding portion of cerebral material is removed, and the dura mater lightly stitched across the gap.

In an **open depressed fracture** the conditions vary much, and the surgical treatment must be modified to meet the requirements of the case. The general plan of treatment for penetrating gunshot wounds may be taken as a model. All patients injured in this way should be X-rayed prior to operation, so that the surgeon may know exactly whether or not fragments of bone have been driven into the brain, and some idea as to their depth may be reached. ✗ Local infiltration anæsthesia by novocain and adrenalin is to be preferred, but gas and oxygen may be administered after a dose of morphia, or ether by Shipway's apparatus; chloroform is contra-indicated.

FIG 368.—PUNCTURED FRACTURE OF SKULL, SHOWING SPOT FOR APPLICATION OF TREPHINE

After shaving and purification of the scalp the margins of the wound should be excised, and provision made for effective exposure of the bone, either by turning down a flap or by enlarging the original wound. The latter plan is that recommended by Cushing—viz., to make three radiating incisions which shall extend out sufficiently far to allow large flaps to be raised, thereby laying bare the bone around the lesion; such flaps can be brought together later on with but little tension and securely sutured.

If the wound is gravely infected, as may happen when delay has occurred, it is wise to excise cleanly the whole of the damaged area of bone by making small trephine or burr holes around it, and connecting them by sawcuts. The loose fragments are then detached from the dura mater and removed *en bloc*; a half-inch margin of dura mater should be left beyond the opening in that membrane. If the surgeon anticipates that the wound infection is not serious, it may suffice to remove the individual fragments of bone and then to trim up the margins of the opening with a rongeur.

The opening in the dura must be handled with the utmost consideration. If torn and dirty the margins may be carefully trimmed; but as little tissue as possible must be removed, since protective adhesions may thereby be broken down, or cortical vessels injured.

The brain itself is gently explored, and foreign bodies or fragments

of bone driven in must be removed. In this stage gentle irrigation with sterilized normal salt solution at a temperature of about 110° F. will be useful, both to wash away disintegrated brain and blood, and to assist in hæmostasis. A large wound may permit of the entrance of a finger, and fragments may be removed by forceps; but for a small penetrating wound a soft catheter should be passed down the track, and softened brain and foreign bodies, or bits of bone, may be sucked up by a rubber ball syringe. Disintegrated brain is removed by this means; normal brain tissue is not affected.

Finally, it is recommended by Cushing that the track should be injected with a small quantity of the oily solution of dichloramine-T (p. 288), and this is also gently applied to the margins of the wound in the dura mater, which is completely closed in suitable cases, or partly closed in others. A drainage-tube or gauze pack may be placed down to the opening in the dura, but not through it. The scalp incisions are completely closed, unless drainage is employed; the more complete and thorough the operation, the less necessary is drainage, and whenever possible, it should be avoided.

Hæmorrhage from the cortex is sometimes troublesome, and if the bleeding vessel cannot be secured, a small fragment of muscle or fascia should be pressed over the bleeding point for some moments till it sticks, and then the bleeding will have ceased.

In civilian cases where a foreign body has been introduced, or a septic penetrating body such as the point of a pickaxe inflicted the wound, the above described procedure will be required. When, however, the lesion is not of this type, but inflicted by a blunt non-penetrating instrument, such as a poker, this elaborate procedure may be simplified, and after removing loose fragments of bone and brain the surface is washed over with hot salt solution, and covered up with dura mater, with or without drainage, as seems desirable.

A small punctured fracture may be included under the crown of a large trephine (Fig. 368), so as to expose the whole of the damaged area, which is more extensive than appears from outside.

In all cases the patient should be confined to bed with the head slightly raised on a single pillow, and the general rules suitable to head injuries followed.

The symptoms and treatment of the intracranial complications of head injuries are dealt with in the next chapter.

CHAPTER XXVII.

AFFECTIONS OF THE BRAIN AND ITS MEMBRANES.

Cranio-cerebral Topography.

IT is scarcely necessary or desirable in a students' manual to deal exhaustively with this subject. The main facts can alone be referred to, and larger textbooks of operative surgery or surgical anatomy referred to for further details.

The *Fissure of Rolando* may be found topographically by the following methods: (*a*) The upper extremity of the fissure corresponds to a point half an inch behind the centre of the line extending from the glabella to the external occipital protuberance (=Chiene's *mid-point*). The direction of the sulcus is downwards and forwards at an angle of about 67° to the middle line. This may be indicated by laying a half-sheet of letter-paper over the skull, the long side corresponding to the middle line, and with its centre over the upper limit of the fissure; the anterior half is now folded over obliquely from this point, leaving an angle of 45° between the front of the paper and the middle line of the skull; and then the same process is again repeated, bisecting the angle and leaving one of about 67°, so that the anterior limit of the folded paper corresponds to the line of the fissure, which is about 3⅜ inches in length. A 'Rolandometer,' consisting of two strips of flexible metal united at the appropriate angle, is now sold by many instrument-makers. As a general rule this 'Rolandic line' crosses the fissure about its centre, being in front of the fissure above and a little behind it below; but it is sufficiently accurate for practical purposes. The centre of the line between the 'mid-point' and the external occipital protuberance marks the position of the parieto-occipital fissure, and a line drawn from this point to the external angular process of the frontal bone corresponds in its anterior portion to the horizontal limb of the Sylvian fissure. (*b*) A less exact method is that defined by Dr. Reid, the measurements for which are all worked from the so-called Reid's base-line, which is one drawn on the skull from the lower margin of the orbit backwards through the centre of the external auditory meatus, reaching the middle line behind just below the occipital protuberance (Fig. 369). From it are drawn upwards two perpendiculars, one (CD) corresponding to the small depression in front of the external auditory meatus, the other (EF) to the posterior border of the mastoid process. The fissure of Rolando

extends from the upper limit of the posterior vertical line to the point where the anterior line intersects the fissure of Sylvius.

To map out the *Fissure of Sylvius*, Reid utilizes a line drawn from a point 1¼ inches directly behind the external angular process of the frontal bone (Fig. 369, A), and about the same distance above the zygoma, to a spot ⅜ inch below the most prominent part of the parietal eminence. The undivided portion of the fissure is represented by the first ¾ inch, and from here the anterior limb (Sy. A. Fiss.) rises vertically upwards for about an inch, whilst the posterior limb extends backwards for the rest of the line. If prolonged to the middle line behind, it indicates with tolerable accuracy the situation of the parieto-occipital fissure (P. O. Fiss.). For other methods of localizing the various intracranial structures, textbooks on Surgical Anatomy must be consulted. Reid's method, although admittedly only approximately accurate, is sufficient from the standpoint of practical utility; for the surgeon in all operations on the cranium always turns down a large flap of bone, and at once the minute details of localization are lost and become unimportant.

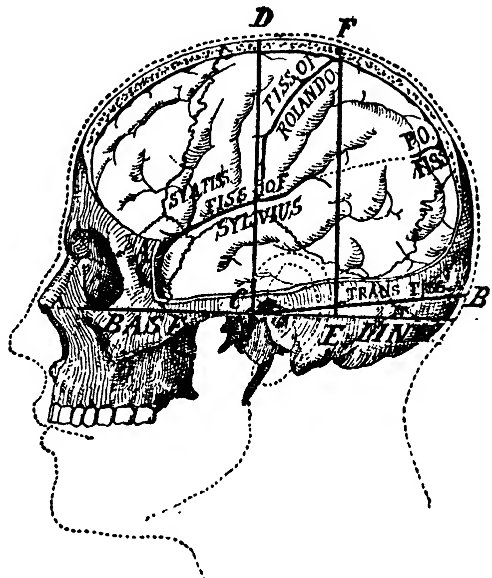


FIG. 369.—DIAGRAM OF HEAD TO INDICATE METHOD OF FINDING THE FISSURES OF ROLANDO AND SYLVIUS BY REID'S METHOD.

Sy. A. Fiss., Anterior branch of Sylvian fissure; P. O. Fiss., parieto-occipital fissure; Trans. Fiss., transverse fissure along line of tentorium; A, external angular process of frontal bone; B, occipital protuberance; CD, anterior perpendicular in front of tragus; EF, posterior perpendicular through back of mastoid process.

Methods of Opening the Cranium.

In the old days but one instrument was employed for this purpose, viz., the trephine; but our increasing knowledge of cerebral lesions and the security given by aseptic methods have necessitated a considerable elaboration in the methods of operating on the cranium.

1. Simple *trephining* is still employed in dealing with lesions where

an extensive exposure of the brain is not required. The modern trephine is often fitted with a solid metal handle to render sterilization easy, and the crown is usually bevelled and not straight, so as to check the liability to slip inwards and wound the dura. The scalp is incised and turned aside by raising a flap which has its base downwards, so as to ensure its vitality. Bleeding is abundant, but is controlled by special scalp forceps (*e.g.*, Sargent's), or by a rubber scalp-tourniquet. The pericranium is stripped from the bone, and the trephine applied with the centre-pin projecting. As soon as a well-marked groove has been made, the centre-pin is withdrawn or removed, and the instrument carried through the cranium. An increased flow of blood will often indicate when the diploe is reached, and care must be taken not to injure the dura. To this end the groove in the bone is carefully examined from time to time by a flattened probe or the blunt end of a needle, and the more so when the operation is undertaken in a region where the bone is known to be of irregular thickness, or if a venous sinus lies beneath it. The disc is removed by an elevator. Considerable bleeding sometimes takes place from the section of the bone, but can usually be controlled by crushing the spot with powerful forceps, or by rubbing in Horsley's wax (carbolic acid, 1 part; oil, 2 parts; wax, 7 parts). If the opening is not sufficiently large, it may be increased by the bone rongeur, Hey's saw or cutting-pliers, or even by the trephine. The use of the trephine may be avoided by employing an electrically driven perforator or burr, which penetrates the skull, but does not injure the dura mater.

2. In many cases of cerebral abscess the trephine is unnecessary, as the causative focus (*e.g.*, mastoid disease or frontal sinus empyema) is first opened up, and the cranial cavity reached by removing portions of bone with a gouge. The same thing occurs in many depressed fractures. When once inside the skull, a bone rongeur or de Vilbiss' punch will suffice to enlarge the opening. Even when the cranium is intact, the gouge is used by some in preference to the trephine to make the first opening.

3. In a decompression operation or for the removal of a cerebral tumour, where a considerable opening has to be made, various plans are adopted:

(*a*) Some surgeons utilize a large 2-inch trephine, but this is obviously undesirable owing to the irregular thickness of the skull, and the difficulty which attends the equal deepening of the groove in all directions over such a large circumference.

(*b*) When it is undesirable to replace the bones, a small trephine hole and enlargement by the rongeur should be adopted.

(*c*) Of late, however, some form of Wagner's osteoplastic method (Fig. 370) has been chiefly used. In this a large flap of scalp tissues is turned down together with the underlying bone, laying bare the dura mater. Probably the simplest way of dividing the bone is to make four small trephine openings at the corners of the flap, and connect these either by the use of a Hey's saw, or by a Gigli saw

(*i.e.*, a piano-wire with a screw-thread turned on it, and with handles attached at each end), passed by means of a probe under the bone from one opening to another; or by the use of a de Vilbiss' rongeur on two sides, whilst the upper end is sawn through by a Hey's saw set on the slant, so that the incision is bevelled, thereby preventing the bone from slipping in when replaced, and the base is divided by a Gigli saw or broken across. This procedure is a serious one, attended by considerable shock and hæmorrhage, and therefore is often undertaken as a preliminary measure a week or ten days before the lesion in the brain is attacked.

Cranioplasty.—Loss of substance of the cranium arises from many different causes (p. 822), and varies both in extent and effect.

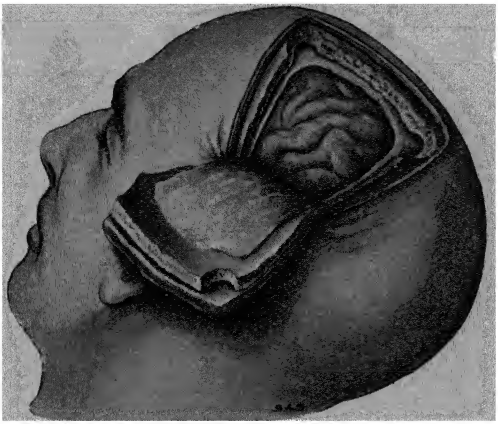


FIG 370.—OSTEOPLASTIC METHOD OF OPENING CRANIUM.

It will be noticed that the flap of skin and bone is larger above than below, thereby facilitating division of the base; openings have been made at each cover by a small trephine, and the base divided; the dura mater has been turned down with the bone flap.

Operation may have to be undertaken for one of two reasons: either to protect the patient from the mechanical risks arising from the presence of the defective area, or to attempt to remedy the effects of intracranial adhesions, etc., in the direction of persistent headache, epilepsy, etc. In the latter case it may be necessary to include the brain itself in the scope of the operation; this feature is referred to elsewhere (p. 882).

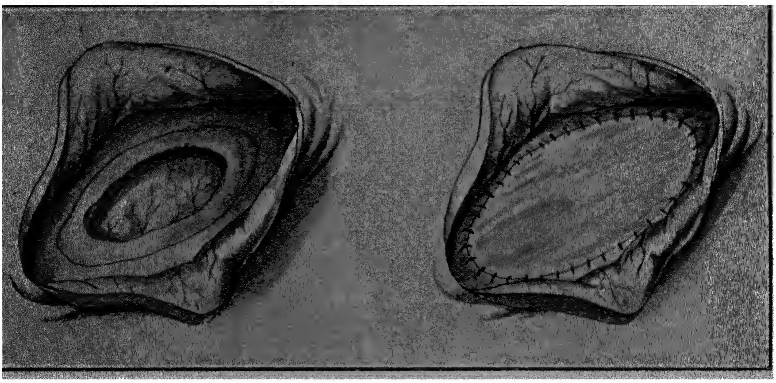
(*a*) Some degree of protection may be ensured by wearing a metal plate over the cranial defect secured in position over the scalp elastic straps, but this is unsightly and unworthy of modern surgery.

(*b*) It is possible to secure a metal plate over the cranial opening by nails or wires, but this often leaves a space between the plate

and the dura mater which fills by scar tissue. It does not free the dura from its attachment to the margins of the opening.

(c) It is desirable in all these cases to detach the dura from the edges of the defect and for a distance of a centimetre or more beyond. The operation consists in turning up or down a flap of scalp so as to expose the defect; care must be taken in dividing the scar tissue which may be present between the dura and the scalp. The dura is then carefully freed from the margins of the opening by a raspatory, and the closeness of this connection is very marked; as soon as the detachment is effected, the dura drops back somewhat, and the cerebral pulsations become evident.

The treatment of the dura and brain is mentioned elsewhere (p. 882). Three chief plans of dealing with the opening may be mentioned. (a) A flap of pericranium and outer table is fashioned so as accurately to fit over the opening. A couple of small drill



FIGS. 371 AND 372.—CRANIOPLASTY BY FIXATION OF A BONY FLAP INCLUDING THE PERIOSTEUM OVER DEFECT IN THE SKULL BY MULTIPLE SUTURES.

holes at each end of the defect through the cranial margins and bone flap permits of the introduction of a mattress suture to fix the flap *in situ*. The scalp is replaced and secured by sutures without drainage. (b) Instead of a bone graft from the neighbourhood, one can be obtained quite well from the tibial subcutaneous surface, or from the outer wall of the ilium including the periosteum (Figs. 371 and 372). It is fixed by a large number of small sutures between the pericranium and the periosteum of the flap. In either case it is wise to freshen up and bevel the margins of the cranial defect by the use of a burr. Excellent results have often followed these proceedings, a good solid skull resulting, and the headache and pain being completely relieved.

(c) A simpler proceeding, and one requiring less technical skill, consists in filling up the opening with flaps cut from a costal cartilage. The dura mater is freed from the bone as described above. The surgeon then exposes the 7th and 8th costal cartilages through

a suitable incision, and cuts from it a strip of cartilage a little larger than the hole in the skull; sometimes for a large defect two or three such strips are required; they vary in thickness up to one-eighth of an inch. These are slipped into the opening so as to occupy the space between the dura and the bone, and are fixed by overlapping the opening on the inner side. The cartilage is believed to remain as such, and protects the dura from re-attaching itself to the skull. Admirable results follow at any rate for a time; the late cerebral symptoms are relieved, although there is but little added cranial protection. Celluloid plates have been used in exactly the same manner, but the late results are often far from satisfactory, and the plates have to be removed.

The Cerebro-Spinal Fluid.

Normal cerebro-spinal fluid is slightly alkaline and as clear as water, with a specific gravity of 1006 to 1008; it contains traces of globulin (not more than ·025 per cent.), and of a copper-reducing substance, and perhaps a few lymphocytes. It is calculated that from 100 to 130 c.c. are present in the normal adult, but this amount is readily increased if there is a free exit as in some fractures of the base, or if the escape is blocked, and the fluid is present under tension.

It is mainly derived from the choroid plexuses of the lateral ventricles, but receives additions from similar structures in the third and fourth ventricles. It appears to be a true secretion, inasmuch as pigments, such as bile, which stain practically all structures in the body, do not pass into it, and various drugs, such as salvarsan, are also held back. The fluid has a definite circulation within the cerebro-spinal space. Starting from the lateral ventricle on either side, it passes down through the Y-shaped foramen of Monro into the third ventricle, and thence by way of the iter into the fourth. Escaping from here through the foramina of Magendie and Luschka, it collects in the cisterna magna, and thence spreads downwards along and around the spinal cord, and forwards along the base of the skull, to occupy the various spaces left between the various elements of the base of the brain. Thence it passes up in the pio-arachnal sheath over the convolutions, dipping with the vessels into the sulci, and giving sheaths along the various nerves as they emerge from the brain and engage the different foramina; it also communicates with the fluid in the internal ear. Finally, it is absorbed into the venous sinuses of the skull through the arachnoid villi and Pacchionian bodies which communicate in large numbers with the interior of the sinuses; some of the spinal fluid escapes into the lymphatics of the nerve roots. It must be remembered that there are no lymphatics in the brain, and that the extensions of the pio-arachnoid along the cerebral vessels serve to remove or supply fluid to it, and a very efficient mechanism for this purpose it is.

The removal of cerebro-spinal fluid has been much employed since Quincke originally recommended it in 1891, and is of the greatest

value both diagnostically and therapeutically. Formerly lumbar puncture was the only method adopted, but now other situations may be utilized for this purpose.

1. **Ventricular Puncture** is one for which considerable skill and special knowledge must be available. The main cavity of the lateral ventricle is situated close to the median line and about 4 or 5 c.c. in front of the upper end of the Rolandic fissure. It may be reached by puncturing the skull with a drill and introducing the needle 1 cm. from the middle line, directing it downwards and slightly outwards; or by placing the puncture 4 or 5 cm. from the middle line, it can be tapped by passing the needle downwards and inwards. The descending and posterior horns may both be reached and tapped, but for these students must consult special textbooks.

The objects for which ventricular puncture may be employed are: (*a*) To withdraw fluid for diagnostic purposes in order to ascertain whether or not the contained fluid corresponds to that in the cisterna or spinal canal. (*b*) To relieve symptoms, such as headache, due to intra-ventricular tension, resulting from lesions at a lower level, *e.g.*, a tumour of the pons. (*c*) To assist in the diagnosis of a cerebral tumour, by replacing the fluid with air and then X-raying the skull (ventriculography). The results of this procedure are still under discussion, but are encouraging.

2. **Cisternal Puncture** has already been alluded to in connection with the diagnosis of tumours of the spine and spinal cord (p. 815). It is also employed for drainage purposes in connection with basal meningitis, and may be of assistance when lumbar puncture fails. A similar procedure has been utilized in some cases of meningitis arising in connection with mastoid suppuration; a radical operation is undertaken and the meninges opened, and it is then possible in some cases to wash the meningeal cavity out from this spot with the assistance of a lumbar puncture, and some excellent results have been obtained.

3. **Lumbar Puncture** is the method of withdrawal of cerebro-spinal fluid most commonly employed. The technique is quite simple: A stout antitoxin or exploring needle should be selected and sterilized by boiling, and the skin in the region of the third and fourth lumbar interspaces (the spinous process of the fourth vertebra is on a line joining the iliac crests) is to be carefully purified. The patient sits or lies with the body well flexed. The needle is then inserted in the fourth interspace, either in the middle line, or a third of an inch from it; it must be pointed forwards, with a very slight inclination upwards. In most cases the needle will go straight into the spinal canal below the termination of the cord, and the fluid will escape. If bone is encountered, it is advisable to withdraw the needle and re-insert it at a slightly different angle. In cases of repeated failure the third interspace may be tried. Under ordinary circumstances the fluid escapes quietly, drop by drop; but in cases of increased tension it may gush out freely.

The characters of the cerebro-spinal fluid vary much in different conditions, both as to quantity and quality, and the study of these is of the greatest help in **diagnosis.** In *acute meningitis*, due to organisms other than the tubercle bacillus, the fluid is under pressure and turbid, containing much albumen. Many cells are present, mainly polymorphonuclear leucocytes, and the causative bacteria may be detected by suitable means. In *tuberculous meningitis* the fluid is almost clear and contains a slight excess of albumen and lymphocytes, but tubercle bacilli are rarely found. The fluid is, of course, under pressure and escapes from the needle in a brisk stream. In *fractures of the base of the skull or of the spinal cord*, in *injuries to the surface of the brain* and in *cerebral hæmorrhage*, blood usually appears around the lower end of the spinal cord within a few hours of the injury, and is intimately mixed with it. For its characters in *spinal cord tumours*, see p. 815; in *anterior poliomyelitis*, p. 516; in *cerebral tumours*, p. 875; in *cerebral abscess* and *lateral sinus thrombosis*, the fluid is normal, but may be under excessive tension.

The **therapeutic** value of this procedure has perhaps scarcely been so fully recognized as its use in diagnosis. In many cases of meningitis the coma is due mainly to excessive cerebro-spinal fluid, and if the amount of this can be diminished the symptoms often abate. The value of lumbar puncture will, therefore, depend on whether or not it is possible to influence the intracranial tension thereby, and that, in turn, is dependent on the situation and character of the adhesions present. The puncture must, therefore, be obviously experimental, as one can never be certain as to the adhesions; but it is a simple proceeding, and may well be employed in all cases of meningitis, in the hope that some good may follow. In traumatic conditions it may be useful when the lesion is not very serious, and the pressure on the brain not hopelessly exaggerated. In cerebral tumours it must be employed with caution, as fatal results have followed the removal of a comparatively small amount of fluid owing to undue pressure on the base thereby induced.

It is also possible to introduce drugs within the spinal theca after lumbar puncture, *e.g.*, stovain or novocaine, for analgesic purposes (see Chap. XLIX.), antitetanic serum or a solution of magnesium sulphate in tetanus, or sodium bromide in delirium tremens. Attempts have also been made to influence by this route parasyphilitic nervous affections where the cerebro-spinal fluid remains positive to the Wassermann reaction in spite of general medication; thus salvarsanized serum, or autogenous blood serum after the use of salvarsan, or a solution of corrosive sublimate, have been injected after puncturing the meninges, but no great success has followed this procedure.

General Conditions of the Brain after Head Injuries.

Concussion of the Brain, or stunning, is a clinical condition, characterized by a more or less complete suspension of its functions as a result of injury to the head, which leads to some commotion of the cerebral substance, and may or may not be associated with hæmorrhage. It varies with the severity of the cause from a slight momentary giddiness and confusion of thought to the most complete insensibility, and is closely allied to shock, from which it is often distinguished with difficulty.

In fatal cases, one finds on post-mortem examination merely the same conditions as obtain in shock, viz., engorgement of the lungs, viscera, and the right side of the heart, whilst the brain presents some lesion of varying severity, from mere punctiform ecchymoses to actual disintegration and disorganization. The symptoms can scarcely be attributed to the injury itself or to a reflex stimulation of the vagus, as they often bear so little proportion to the degree of mischief.

Many theories of concussion have been formulated, but that of Trotter seems to answer best most of the difficult questions that arise. He attributes the condition to 'hyperacute general compression of the brain.' When a severe blow is applied to the skull, this necessarily entails a diminution of the cranial capacity which takes place at the expense of the fluid contents. The whole brain at the moment of contact becomes squeezed like a sponge, and owing to the severity of the blow the resistance offered by veins, capillaries, and arteries is practically the same; the result is a widespread anæmia, and this produces, as has been shown by Cushing, paralysis. The state of severe concussion is understandable if it is considered as an anæmia of the brain of very short duration, with immediate widespread paralysis, which has a tendency to pass off spontaneously.

The **Symptoms** vary considerably in degree, but in a well-marked case the stage of concussion is evidenced by unconsciousness, more or less complete, although the patient can sometimes be roused by shouting; he lies on his back, with the muscles relaxed and flaccid; the eyelids are closed, and the conjunctivæ may be insensitive; the pupils vary, but are equal and often contracted, usually reacting to light; but in bad cases they are dilated, and do not contract when light is admitted. The surface of the body is pale, cold, and clammy. The respirations are slow, shallow, and sighing, whilst the pulse is rapid, weak, fluttering, and scarcely sensible to the fingers; the temperature is at first subnormal; the sphincters are relaxed, with perhaps unconscious evacuations from both bladder and bowel. The reflexes are present in the milder cases, though sluggish; in the more severe they may be entirely absent.

This condition may last for a considerable time, and then pass slowly into more profound unconsciousness and death, or be followed by the phenomena of inflammation, compression, or cerebral irritation. In the simpler cases, however, *reaction* soon begins to manifest itself. The patient is presumably put to bed, and warmth carefully

applied to the extremities. The first sign of reaction is probably a slightly increased rate of both breathing and pulse, and he may be able to tell his name and address; sometimes he turns on his side, and pulls the bedclothes up to his face, since he feels cold and chilly as a result of the cutaneous anæmia. Gradually he becomes more and more rational, and the functions of both mind and body are restored, reaction being fully established by the occurrence of vomiting, due to a condition of cerebral hyperæmia following the anæmia. Probably he suffers from headache for some days, and a slight amount of fever will follow; but this passes off, and leaves the patient either quite well, or with a somewhat irritable brain requiring prolonged rest. Subsequent events may, however, prove that more mischief has been done than appears at first. Thus, some special function of the brain may be permanently lost or impaired, such as memory, hearing, or vision; a patient may forget the names of places or persons, or may lose all memory of time; speech may become defective or stammering, or a certain amount of asthenopia (weakness of vision) may supervene. Such individuals are very liable to develop signs of mental instability, and even delusional insanity or melancholia, if placed in positions of responsibility or strain. Others seem to suffer from a general loss of nerve tone (neurasthenia), rendering them incapable of fulfilling their ordinary duties in life. In all the more severe cases there is a complete lapse of memory as to the accident, and even as to the events which preceded and follow it, extending sometimes to a fortnight or more, and perhaps including a period during which the patient was apparently quite rational. Not a few of the post-concussion phenomena, however, are functional in origin, and can be treated by suggestion.

The **Treatment** of concussion very closely resembles that of shock, viz., the patient is at once put to bed with the head low. If conscious, he may be given a drink of hot tea, but needless stimulation must be avoided, for fear of exciting hæmorrhage; an enema of hot coffee may be administered, or, if *in extremis*, brandy, or a hypodermic injection of strychnine. A good purge, such as 5 grains of calomel, or a drop or two of croton oil on sugar, should be administered after reaction in the milder cases, but while still unconscious in the graver forms. It is most important that the patient be kept quietly in bed for at least ten days or a fortnight after a moderately bad concussion, and free from all sources of worry and irritation, even though he feels quite well. The diet must be restricted, and the bowels kept open. 'Make haste slowly' is here a golden rule.

When the unconsciousness is prolonged, and no signs of fracture of the cranium exist, lumbar puncture should be employed, and may be most beneficial. Thus, a lady who had attempted suicide by throwing herself from a window lay for two or three days on the borderland of unconsciousness, frequently relapsing into a comatose state. Lumbar puncture resulted in the drawing off of some drachms of blood-stained fluid, and at once restored her to complete consciousness, which was not again lost. Should this treatment

fail, the head should be shaved, and an icebag applied; the bowels are opened regularly, and the state of the bladder attended to; the room must be kept dark and quiet, the attendants making as little noise as possible in walking and talking, etc.; sufficient nourishment must be given either by a spoon if the patient can thus take it, or by nutrient enemata or a nasal tube.

Cerebral Irritation.—By cerebral irritation is meant a clinical condition which sometimes follows concussion, characterized by great irritability of both mind and body. It usually results from blows or falls on the temple, forehead, or occiput, and is probably due to a superficial laceration of the brain, possibly in the frontal region, and to the hyperæmia caused by its subsequent repair.

The **Symptoms** are very characteristic, and usually manifest themselves two or three days after the injury, though sometimes earlier. The patient lies on his side in a condition of general flexion, the back arched, the legs drawn up to his abdomen with the knees bent, and the hands and arms drawn in. He is restless, and may toss about, but never extends himself fully or lies supine. The eyes are closely shut, and he resists all attempts to open them; the pupils are contracted; the temperature is usually a little raised; but the surface of the body and head are both cool; the pulse is quiet, but weak; the sphincters are usually in a normal condition, and the excreta are often passed in the bed, but the bladder may occasionally need to be emptied by catheter. In some mild instances the patient may get up to empty his bladder and then return to bed. He is by no means unconscious, but takes no heed of what is passing around, and is intensely and morbidly irritable. When disturbed, he will gnash his teeth, frown, swear, and resent the intrusion in the most expressive manner. At the end of a few days, or perhaps after a week or two, a marked alteration in the condition of the patient usually shows itself. He is less irritable, begins to stretch himself out, and with this is conjoined an improvement in both pulse and temperature. Sometimes he becomes childish, and needs to be taught the names of persons and things; at other times he is garrulous, perhaps giving a fresh story of his accident every day, but generally there is an absolute lapse of memory in this direction. Usually the brain recovers in time, but serious after-effects in the direction of chronic meningitis or mental aberration are likely to ensue.

Treatment.—The patient is kept quiet and free from noise and excitement; his diet must be light and nourishing. The head should not be too low, and an icebag may be used if the patient will permit it. The bowels are kept well open, and this is best done by saline purges on account of their dehydrating action, which helps to reduce the œdema of the brain; sedatives such as bromide may be useful. When the irritable stage is prolonged, subtemporal decompression should be performed. This frequently affords relief to the œdematous brain, with restoration of the normal circulation.

Compression of the Brain.—Compression is the term given to a clinical condition due to some abnormal and excessive intracranial pressure which disturbs the functions of the brain. In the earlier

stages the blood in the veins and venous sinuses, with the cerebro-spinal fluid, are forced out of the cranial cavity, and a position of equilibrium may be reached; but as the pressure increases, venous stasis first develops, causing cyanosis of the brain with its accompanying irritative symptoms, and later anæmia ensues with its paralytic symptoms.

When of traumatic origin, it may arise from the following causes: (*a*) Depressed bone or the presence of a foreign body, in which case the symptoms of concussion merge directly into those of compression, and usually without any interval of consciousness. It is probable, however, that in these cases the symptoms are due more to the associated hæmorrhage than to the actual cranial lesion. (*b*) Extravasation of blood within the cranium, either outside the membranes, or on the surface of the brain, or within its substance. If the bleeding is extradural, there will probably be a short interval of consciousness between the concussion and the compression; if the bleeding is cerebral, the symptoms of compression may manifest themselves at once without any interval being noticed. (*c*) It may be due to an acute spreading œdema, the explanation of which is subsequently given. (*d*) It may arise from the pressure of inflammatory exudation or pus, in which case the symptoms are preceded by those of inflammation, and at the earliest will not manifest themselves before the third day, but they may be deferred for a week or two.

Compression also arises as a result of idiopathic hæmorrhage, tumours, gummata, or abscesses—*e.g.*, of middle-ear origin.

The **Symptoms** of compression are essentially those of *coma*. When the condition is well established, the patient lies on his back absolutely unconscious, and cannot be roused either by shouting or shaking. His *breathing* is slow, laboured, and stertorous, the lips and cheeks being puffed in and out. The stertor arises from paralysis of the soft palate, and the puffing of the cheeks from paralysis of the facial muscles. In the later stages the respirations become irregular, and take on the Cheyne-Stokes type. Gradually breathing becomes more shallow and difficult, and death finally arises from cessation of the respiratory act. The *pulse* is full and slow at first from irritation of the vagus and vasomotor centres, but later on becomes rapid and irregular, owing to increased pressure upon and exhaustion of these medullary centres. The *surface* of the body may either be cool, hot, or perspiring; the *temperature* similarly varies, often being low in the early stages and higher at a later date. Not unfrequently the fatal end is associated with marked hyperpyrexia. In some cases where the compressing force is unilateral, there may be some difference of temperature on the two sides of the body. The *pupils* vary according to the degree of compression and the situation of the compressing agent. If the cerebral pressure is equally diffused, both pupils first contract, and then gradually dilate and become reactionless; but if one hemisphere is affected more than the other, the pupil on that side passes rapidly through these changes, whilst on the opposite side they are not developed until later. Thus, it is a common thing to find the pupils unequal in size, and reacting

differently to light. The whole body in the later stages is in a condition of *motor paralysis*, but at an earlier period of the case there may be some difference on the two sides if the lesion is unilateral; thus, if the left side of the brain is primarily affected, a right-sided hemiplegia is likely to be present at a time when the muscles on the left side can still respond to cerebral stimuli. A localized compression involving the motor area may lead to convulsions in the corresponding group of muscles. The voluntary control over the bladder is lost, and hence retention ensues; the sphincter ani is often relaxed, and fæces pass involuntarily, although marked constipation is usually present.

The symptoms in some cases are ushered in by severe pain or headache, which is partly due to pressure upon and tearing of the dura mater, and partly to the altered vascular conditions of the brain; the brain substance itself is not sensitive, and hence the pain is not directly referable to any lesion of or pressure upon it. Naturally, the clinical picture is modified according to the cause of the compression, even as the course of the case varies widely according to whether or not the compressing agent can be removed by the surgeon, or absorbed by natural processes.

The **Diagnosis** of coma from compression, when a complete history of the case can be obtained, is often easy, and, indeed, the whole clinical aspect may be so typical that no question as to the cause of unconsciousness can be raised. But when a person is found in the streets unconscious, and no history either of the patient or of an accident is obtainable, and no serious lesion of the skull is present, the diagnosis is often extremely obscure, since coma may be due to many other causes, *e.g.*: (*a*) Cerebral lesions, such as apoplexy, whether the result of hæmorrhage, embolus, or thrombosis; or it may be the consequence of a preceding epileptic fit, or due to a rapidly spreading œdema in cases of cerebral tumour or abscess. (*b*) Various toxic agents may induce coma; they may be introduced into the system from without, as in the case of alcohol, opium, or other narcotics, or may be developed within the body, as in uræmia or diabetic coma. (*c*) Heatstroke or exposure to cold may also lead to unconsciousness. In the latter case there can be but little doubt as to the cause, since the patient is cold, pale, and in a state of severe prostration; in the former the diagnosis may for a time be doubtful. (*d*) Lastly, it must not be forgotten that two or more of these conditions may co-exist. Thus a drunken man may fall and break his skull, and then the smell of liquor in his breath may lead to an erroneous diagnosis.

It is therefore evident that a very thorough examination is required before any conclusion can be arrived at as to the cause of the coma, and it is often impossible to make an immediate diagnosis. In such cases the patient should be carefully tended and watched, and not shut up in a police-cell without attendance.

The following points should always be observed in the examination: (1) A rapid note should be made as to the surroundings of

the patient—whether there is blood or vomit near him, how the body is lying, and the nature of the ground. (2) The depth of the coma should be tested, and, if possible, the man should be roused, and asked to give an account of himself. (3) A most thorough and complete investigation should be made as to his condition. The skull is first examined, to settle if possible whether a fracture is present; the surface temperature is noted, as also the character of the pulse and respirations. The tongue should be looked at, as it is often bitten in an epileptic fit. The smell of alcohol in the breath is not sufficient warrant in itself to diagnose merely drunkenness, as the alcohol may have been given after the accident. The condition of the pupils may throw some light on the case; in opium-poisoning they are small and equal, a condition also seen in hæmorrhage into the pons; in alcoholism they are often dilated and fixed, but vary considerably. The amount of power and the state of the reflexes are then observed, any inequality probably indicating a unilateral lesion in the brain. The urine must be drawn off, and examined for albumen and sugar. (4) In dubious cases, and especially where there is any suspicion of drunkenness or poison, the stomach should be washed out. (5) Finally, if the cause is still uncertain, the patient should be put to bed and carefully watched.

The **Treatment** of compression must be, where possible, directed to removing the cause. When it is due to depressed bone or a foreign body, immediate operation is required; collections of pus should be opened, and blood-clots removed. Failing such measures, and if lumbar puncture gives no relief, the treatment of the condition itself resolves into keeping the patient quiet, with the head low and cool, the room dark and noiseless, the bowels open (using croton oil on sugar, or enemata, for this purpose), and the bladder empty. The patient may be fed by rectum, and if the breathing or pulse is very laboured, and cyanosis begins to show itself, venesection may be advisable. Considerable interference with the respiration arises from falling back of the tongue, as often occurs in profound anæsthesia during operation, and if due to this cause the head may be rolled over to one side, or the tongue pulled forwards.

Laceration of the Brain.—Injuries to the brain and its membranes are frequent complications of head injuries, and all the most serious results of these accidents arise from this source. They are produced in many different ways, and cause varied symptoms; but the most important distinction to draw is between those wounds which communicate with the exterior and those which do not.

I. **Non-penetrating Wounds of the Brain** result from blows and falls, which may or may not produce simple fissured or depressed fractures of the skull, but not unfrequently the most serious cerebral symptoms follow injuries in which the bones do not participate. In depressed fractures the brain is usually most contused or torn immediately below the injured spot; but in cases where there is no depression, the greatest mischief is frequently found at a point

exactly opposite to that struck (point of *contrecoup*), whilst the local bruise may be much slighter. Thus, in the case of one of our students who in an epileptic fit fell, striking the left occipital region on a stone pavement, we found *post-mortem* a fissured fracture at the spot struck and a bruise on the left occipital convolution, whilst the anterior portion of the right frontal lobe was severely contused, and, indeed, disintegrated. The explanation of this fact is that the force of the injury is transmitted to the brain substance in a wave which concentrates its violence against the opposite side of the skull. In very sharp sudden localized blows, as from a spent bullet, local bruising of the subjacent brain may be alone produced.

Pathological Anatomy.—The *immediate* effects of such an injury vary considerably. There may be a mere bruise, evidenced by a few points of extravasation, on the surface or in the gray matter; or the more superficial parts of the brain may be totally disintegrated and mixed with clots; or, if laceration has occurred, clots may be found adhering to the injured spot, or extending from it widely into the subarachnoid space, or even, under rare circumstances, into the lateral ventricle. The *later* effects in cases where the wound does not communicate with the exterior are mainly those of inflammation or degeneration. Soon after the accident considerable exudation follows, causing the ecchymosed brain substance to swell and become œdematous; this may speedily subside, but in the more serious cases a *spreading œdema* may be caused, owing to the pressure of the swollen tissues upon the superficial veins in the pia mater; the circulation in these is hindered, and increased exudation follows, leading to general cerebral pressure and even death, a consequence hastened by the excess of cerebro-spinal fluid usually induced by the process. Under such circumstances the greater part of the brain is œdematous and glistening, the injured area being yellowish-red in colour, with evident points of extravasation scattered through it. Still later, degeneration of the brain substance may follow owing to the disturbance of its circulation, and is indicated by the presence of a pulpy yellowish mass, soft enough to be washed away by a stream of water, and containing fat globules and granular cells, with débris of nerve fibres (*yellow softening*). If the area involved is small and unimportant, the patient may recover, the softened tissue being absorbed, and replaced by a scar; if large or implicating important centres, death or paralysis must ensue. In cases of laceration of the brain which recover, a tough depressed cicatrix is formed, usually adherent to the membranes, and containing hæmatoidin crystals, whilst extravasated blood may be organized into a dirty brownish lamina, adherent to the pia mater, or into an arachnoid cyst.

Clinical History.—The symptoms necessarily differ with the severity and locality of the lesion.

Whenever concussion occurs after a head injury, and the patient recovers slowly from it, the surgeon will rightly suspect contusion or laceration of the brain. In the slighter cases recovery is often

inaugurated by an attack of vomiting, and this is followed by a rise of temperature to about 100° F. for a few days, whilst the patient complains of fixed pain and headache, which under suitable treatment may entirely disappear. Some impairment of sense or of function, however, may persist.

More serious lesions give rise to various symptoms resulting from hæmorrhagic effusion, and these develop either at once or within twenty-four to forty-eight hours of the injury. Thus, if the phenomena of compression supervene at once, without any interval of consciousness, a diagnosis of depressed bone or a serious hæmorrhage into the cerebral substance may be safely made. If, on the other hand, the patient rallies for a time before becoming comatose, an extradural hæmorrhage from the meningeal vessels or venous sinuses may be suspected. Moreover, the possibility of a rapidly spreading œdema ought not to be forgotten.

Hæmorrhage into the cortex is characterized by irritative or paralytic phenomena, which vary with the cortical area involved. The degree of unconsciousness depends on the amount of the hæmorrhagic effusion.

In the *Upper and Middle Frontal Convolutions* neither motor nor sensory symptoms are noted, but cerebral irritation and subsequent weak-mindedness are likely to follow, especially if the left side is involved; lesions to the right frontal lobe do but little harm to a right-handed individual. Apparently, the intellectual faculties, as well as speech, are limited to one side of the brain.

Wounds of the *Third Left Frontal Convolution* lead to motor aphasia—*i.e.*, the inability to produce or articulate words, in right-handed individuals; in left-handed people wounds of the right side have a similar result. Injury to the opposite convolution has no effect. If only one side is damaged, the other can after a time be educated so as to take on its function.

Hæmorrhage into the *Motor Area* results in localized convulsions or paralysis, according to the degree of mischief. If the bleeding is progressive, a regular extension of the convulsions may be witnessed, the movements commencing, perhaps, in some region which is at the time incapable of voluntary movement, and spreading to other parts of the body. Thus, if bleeding is occurring into the cortical centres for the face on the left side of the brain, paralysis of the right side of the face may be present, and it is here that the convulsions will start, spreading regularly to the right side of the neck, arm, and leg, and then involving the left leg, arm, and side of the head in order, finally becoming general, as in an epileptic fit. After each convulsion the paralysis is found to have spread.

It is sometimes very difficult to diagnose between a true cortical hæmorrhage and one which extends diffusely over the cortex in the subarachnoid space from the rupture of a vein in the pia mater. In the latter, however, the symptoms develop earlier, the paralysis is less marked, and the convulsions are less regular, though perhaps more generalized.

An irritative lesion of the motor area for the head and eyes causes a conjugate deviation of the eyes towards the other side; a destructive lesion causes both eyes to be deflected towards the injured side. The posterior wall of the fissure of Rolando is concerned with cutaneous, muscle and joint sensibility.

Wounds of one *Occipital Lobe* may cause a temporary homonymous hemiopia, but no persistent loss of vision, unless the angular

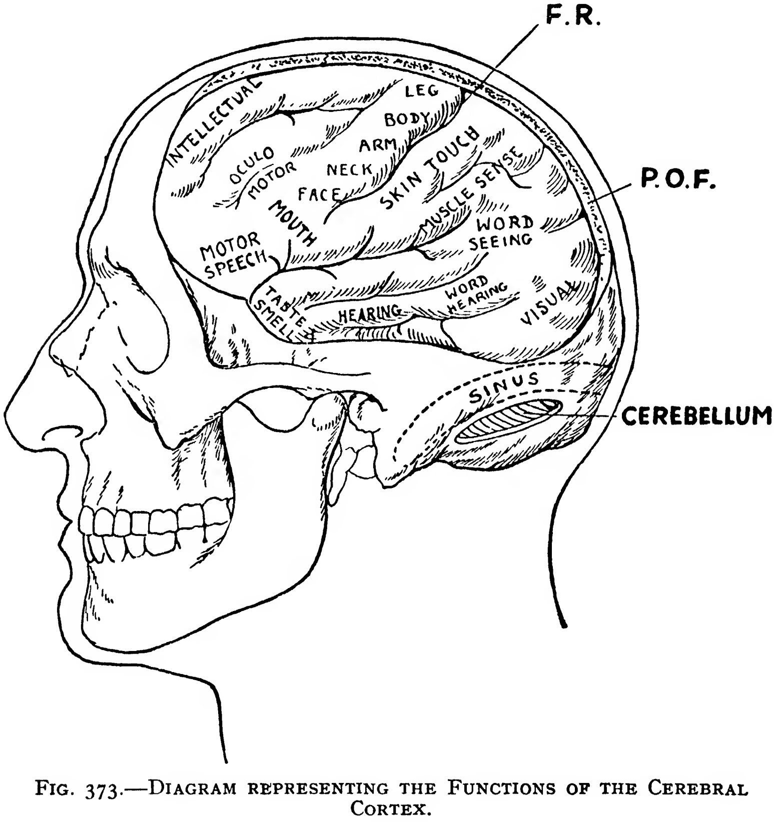


FIG. 373.—DIAGRAM REPRESENTING THE FUNCTIONS OF THE CEREBRAL CORTEX.

F.R., Fissure of Rolando; P.O.F., parieto-occipital fissure.

gyrus is also destroyed. Lesions of the latter region are always associated with permanent disturbances of vision.

The *Upper Temporo-sphenoidal Lobe* contains the cortical auditory centre, and lesions in this region cause deafness. The sense of smell is located in the anterior portion of the lower temporo-sphenoidal lobe which constitutes the uncinate process.

Injury to the *Corona Radiata* leads to paralysis of the regions repre-

sented by the overlying cortex, but without convulsions or other irritative phenomena. If the corpus striatum or internal capsule is torn or involved in a hæmorrhage, coma rapidly supervenes, accompanied by hemiplegia and perhaps hemianæsthesia. Occasionally the effused blood bursts *into the lateral ventricle*, and causes a rapid rise of temperature, increasing until the patient's death, together with a very rapid weak pulse and increased respiratory rate (40 to 60 per minute).

Wounds of the *Cerebellum* cause giddiness, vertigo, ataxy and nystagmus, the patient reeling about in characteristic cases, as if drunk, and if the lesion is unilateral, falls to the side of the injury.

A wound of the *Crus Cerebri* occasions more or less complete hemiplegia of the opposite side of the body, associated with some amount of hemianæsthesia, and total paralysis of the 3rd (oculo motor) nerve on the side of the injury.

Laceration or contusion of the *Pons Varolii*, if not immediately fatal, may lead to paralysis of the opposite side of the body, together with paralysis of the 5th, 6th, 7th, or 9th nerves, on the same side as the lesion, constituting the so-called 'crossed paralysis.' Marked contraction of the pupils (myosis) may also be present.

Wounds of the *Medulla* are usually fatal. If, however, the patient should escape, he is liable to suffer from disturbed functions of the circulatory and respiratory centres, with perhaps Cheyne-Stokes respiration and glycosuria.

Pyramidal Signs.—Motor impulses are conducted from the cortical motor areas to the muscles chiefly by the pyramidal tract. From the motor cells in the cortex the fibres converge through the corona radiata into the internal capsule, thence after passing through the pons and medulla cross to the other side of the body and terminate in the anterior horn cells. Lesions of the cerebral portion of this tract produce a certain degree of hemiplegia, varying from slight paresis to complete paralysis. At the commencement there is usually flaccidity of the affected side, which in a week or ten days is succeeded by hypertonicity with a tendency to flexion of the upper limb and to extension of the lower. Clawing of the hand which gives the sensation of elastic resistance becomes progressive from the onset of the hypertonicity. The platysma may be observed to contract more energetically on the sound than on the paralyzed side, and the tongue deviates slightly to the side of the paralysis. The deep reflexes are usually more active on the paralyzed side. The alterations in the cutaneous reflexes are particularly significant. The plantar reflex gives an extensor response (Babinski sign), and the abdominal reflexes on the paralyzed side may be either diminished or absent. Other signs of less importance may be found in textbooks dealing with the subject.

The **later results** of a cerebral laceration vary much. The patient may recover perfectly after a more or less prolonged period of unconsciousness, but not unfrequently some loss of power persists, which will seriously impair the patient's subsequent usefulness.

The febrile phenomena already mentioned as characteristic of the first few days of convalescence after an attack of concussion may pass into a condition of subacute or chronic localized inflammation of the injured area, as indicated by pain and headache. In such cases the inflammatory effusion may be so abundant as to determine the onset of unconsciousness in four or five days. Occasionally an abscess forms deeply in the white substance, and this will be indicated by the usual phenomena of such a condition, coming on ten or fourteen days after the injury.

The formation of cicatrices between the brain and membranes may determine the development of traumatic epilepsy or insanity at a later period (p. 881).

The **Treatment** of these cases is always an exceedingly anxious matter for the surgeon. In the majority of instances it is merely symptomatic, following the usual course adopted in concussion, compression, cerebral irritation, etc., as indicated elsewhere. Depressed bone, if present, will, of course, be dealt with by operation. Early convulsions and paralysis are carefully watched to see if any indication as to the site of the bleeding can be obtained, since it is possible that trephining over the injured spot and removing blood-clots or securing bleeding-points might be advisable; but the clinical records of such treatment are not very encouraging. Late convulsions and paralysis due to inflammation are best treated by shaving the head and applying an ice-cap, and by lumbar puncture. If the pulse is full and hard, and the patient otherwise young and healthy, general venesection may be adopted; the bowels must be moved by a smart purgative, such as croton oil, whilst bromide in full doses may be administered. If the convulsions continue in spite of such treatment, and become more severe and extensive, the patient will almost certainly die of coma; trephining over the injured area is then distinctly indicated, the surgeon hoping to find and remove some clot, or, at any rate, to relieve tension by decompression.

In quite a number of these cases a *subtemporal decompression* is indicated. The patient has recovered from his concussion, but remains in an irritable, semi-conscious condition, noisy and restless at times, and at other times more or less comatose; his mental condition is bad, and the bodily functions irregular. Lumbar puncture is sometimes useful, but the patient is so restless that it is dangerous to do it apart from a general anæsthetic, and repeated administrations are undesirable. When no localizing symptoms are present (and this is often the case), the skull may be advantageously opened beneath the temporal muscle which is turned down for the purpose; a free removal of bone follows, extending antero-posteriorly rather than transversely; and the dura mater is opened. In this type of case the brain pulsations cannot usually be felt before incising the dura: a free flow of cerebro-spinal fluid follows the incision in most cases, and the brain pulsations are then at once re-established. The dura is turned back in flaps and stitched aside, and the temporal muscle laid down again in place and fixed by sutures.

The skin incision is closed without drainage. The effect of this procedure is to provide a permanent relief of tension to the intracranial space in a comparatively safe position. In some cases of this type definite fulness in the temporal fossa is noticed for a time. The patient in favourable cases loses his headache, and becomes quiet and rational in a short time. In one instance the patient expressed himself as more capable of mental concentration after this operation than he ever had been before his accident (air-crash).

It may, however, be desirable in supposed cases of cerebral œdema to employ the intravenous injection of a hypertonic saline solution prior to operation. The cerebral tissue is one of the most sponge-like structures in the body, readily absorbing and quickly giving up fluid to the pio-arachnal prolongations which accompany the vessels in their distribution. The call to dilute the hypertonic solution injected into the blood-stream will first be answered by the loose fluid contained in the cerebral substance, and may remedy the coma induced thereby.

II. **Penetrating Wounds of the Brain** result from blows or falls, as in compound depressed fractures; or from the entrance of foreign bodies, such as bullets, shrapnel or shell fragments, or from stabs or punctures, which most commonly occur in the weaker parts of the cranium—*e.g.*, the temple or upper wall of the orbit; or from sabre-cuts or axe-wounds, in which an oblique or almost valvular incision is made through the scalp and cranium, laying bare and wounding the brain and its membranes.

In some cases where the skull has sustained a considerable degree of injury, and a large opening results, the general disturbance is often slight, compared with the extent of the local injury, so that, although brain substance may protrude from the wound, there is sometimes but little concussion. The chief dangers arise when the opening is but small. Any of the conditions due to hæmorrhage detailed below may follow, but they may be slight if the blood can escape from the wound. The inflammatory phenomena due to *infection* of the wound may be localized or diffuse. In the latter instance general meningo-encephalitis manifests itself in the course of two or three days, and is rapidly fatal; in the former case adhesions prevent the extension of the trouble beyond the neighbourhood of the wound. Hernia cerebri is very likely to follow, and possibly a deep cerebral abscess may complicate matters at a later date. In cases that have been successfully rendered *aseptic*, the course is similar to that run by a non-penetrating wound, except that, if anything, the immediate prognosis is better, since the opening in the skull diminishes the likelihood of compression from simple or spreading œdema. Where the lesion has involved the motor area, permanent monoplegia may persist, and later symptoms are always liable to arise owing to the formation of cortical adhesions.

Treatment.—In all cases of punctured or compound depressed fracture, a thorough exploration of the wound should be made. and

all depressed or injured bone removed. Foreign bodies should be taken away, if found close to the wound, and often the mere removal of a superficial blood-clot from the mouth of the track will permit the brain to 'vomit' out deeper clots and even fragments of bone, or small foreign bodies. The method of sucking up broken-down and disintegrated brain tissue by a catheter and ball syringe has already been alluded to (p. 837). Bullets or large shell fragments, or foreign bodies, ought to be removed if within two inches of the surface (P. Sargent); but if deeper, they should be left alone, unless there is a definite and easily followed track leading to them. Protruding brain tissue is washed with hot normal saline solution and left *in situ*. Bleeding-points in the brain are controlled by pressure over small flaps of muscle or fascia; but the application of a swab wrung out of hot saline solution should be first tried. The dura mater should, if possible, be drawn together by one or two sutures, and the scalp-wound is closed, if possible completely, so as to avoid the use of drainage on account of the risk of infection entering through the drain opening; if employed, the gauze or tube should be removed, when all is going well, in about two days' time. If the temperature rises as a result of infection, the wound must be re-opened, and every effort made to relieve tension, and thus localize the mischief. Lumbar puncture should be frequently undertaken, and the fluid examined for organisms; an autogenous vaccine has been found useful in some cases. Should diffusion occur, as indicated by an increasing severity of the symptoms, the patient must be treated in accordance with the general principles laid down for dealing with acute meningitis.

It is imperative that from the earliest possible moment the patient should be placed under the influence of bromides in order to quiet him and protect him from the risks of epilepsy.

In this description of lacerations of the brain the fact that symptoms may arise from inflammatory conditions affecting the bones (p. 824) has been purposely omitted. In actual practice the course of events is often considerably modified by such complications.

Later Management of Head Cases.—All injuries involving the skull and associated with cerebral symptoms must be regarded as of a serious nature, and the patients before being discharged from medical supervision should be warned as to the course of life that is desirable, and the restrictions that should be observed; these naturally are more urgent in the more serious cases. Thus after a penetrating lesion of the brain, such as occurs in gunshot wounds, and in particular if there is a marked cranial defect, or if the patient has recovered from a hernia cerebri, he should be advised to live as quiet and regular a life as possible; the country is to be preferred, so as to avoid the hurry and bustle of town life; alcohol is absolutely forbidden; sexual excitement must be avoided; the diet should be simple and unstimulating; the bowels must be kept regularly open. Light work may perhaps be undertaken which does not involve hanging the head downwards, or overstrain, mental or physical.

Fatigue and exhaustion are to be avoided, and the patient must indulge in plenty of sleep. Hot and badly ventilated rooms are undesirable, and places of public recreation are best avoided. Cinema shows are extremely bad, the vibratory movements of the pictures disturbing the patient's sense of equilibrium. The head should be well protected in hot weather, and these patients should not be sent abroad to hot climates. In fact, the patient after a bad head injury must develop a 'vegetable' type of life for a while, and nothing can be much better than light work on a farm for a year or two. Gradually as the brain recovers tone, the ordinary stress and strain of life may once again be taken up.

In spite of such care, or more frequently owing to the want of it, many patients who have sustained penetrating wounds of the brain from which they have recovered as a result of an effective decompression, begin to experience after a while symptoms, partly due to the injury, partly to the after-results of the operative treatment. They complain of headache more or less constantly, varying in degree with the amount of excitement and noise around them; they also suffer from anorexia and constipation, and perhaps from vomiting. They are unable to concentrate their attention on reading or games, and become morose and irritable. Possibly epilepsy supervenes, and if the motor area is involved this may be of the Jacksonian type. Vision is often defective owing to paresis of accommodation, and they may complain of giddiness and noises in the head. Some of these symptoms are undoubtedly functional, but others are very genuine results of the local lesion. Occasional exacerbations occur if the patient is exposed to cold and fatigue; he may even become unconscious and die.

The head wound is usually found to be tense, and no cerebral pulsations can be felt; the opening in the skull is closed by a firm scar which is attached to the margins of the cranial defect; it may even bulge outwardly during the more severe attacks.

These cases may be improved by keeping the patient quiet and giving him bromides; attention to the bowels is also desirable. Few of them will improve permanently unless the dura is freed from the cranial attachments, and some form of cranioplasty (p. 841) is almost always necessary. If no operation has been undertaken at the time of the injury, a number of these cases are greatly improved by subtemporal decompression.

Injuries to the Intercranial Bloodvessels.

1. **Wounds of the Venous Sinuses** are by no means uncommon, being torn across in fractures, or punctured either by some sharp instrument, or by spicules of bone. The superior longitudinal, petrosal, lateral, and cavernous sinuses are those most frequently involved, especially the first, because it is more intimately connected with the bones than any of the others. Not unfrequently a depressed

interval of consciousness varies widely, but it is not often longer than an hour or two, whilst in many cases it is scarcely recognizable. On the other hand, cases are known where symptoms were delayed for days or even weeks after an injury. As accessory signs, the following may be mentioned: (1) Since the blood-clot is situated close to the motor area of the cortex, and especially over the centres of the head and arm, twitching of these parts, followed perhaps by paralysis, may be a well-marked feature, and usually supervenes before the onset of coma; (2) when the clot extends to the base of the skull, it presses on the cavernous sinus, and may induce passive congestion of the eyeball, paresis of some of the ocular muscles, and proptosis, with possibly a dilated pupil and high temperature; and (3) when a fissure exists in the bone, blood may filter through into the temporal fossa, and cause a marked fulness in that region. The **Prognosis** is extremely unfavourable, Von Bergmann stating that out of ninety-nine cases only sixteen recovered.

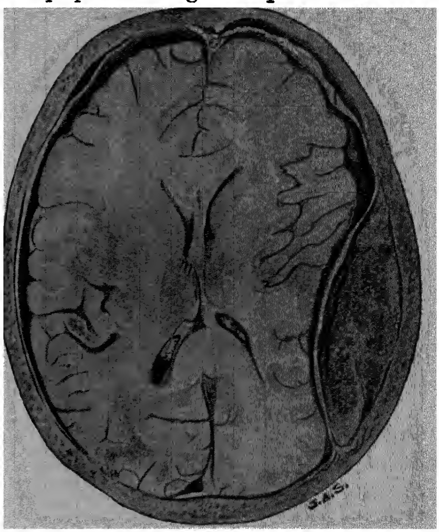


FIG. 374.—MENINGEAL HÆMORRHAGE (FROM SPECIMEN IN COLLEGE OF SURGEONS' MUSEUM)

The **Diagnosis** of extra-dural as distinct from intra-dural hæmorrhage is by no means simple. The latter is usually more rapid in its onset, and if involving the motor area may be associated with definite cortical phenomena; it is likely to be associated with blood-staining of the cerebro-spinal fluid; unfortunately, the two conditions not unfrequently co-exist.

The **Treatment** consists in trephining in order to remove the blood-clot and secure the artery, if still bleeding. The spot selected for dealing with the anterior division of the artery is 1½ inches behind the external angular process of the frontal bone, and 1½ inches above the zygoma (Fig. 37[illegible], F), and this point may be marked on the bone with a bradawl through the scalp before commencing the operation. The scalp is shaved and thoroughly purified, and a ∩-shaped flap turned down, including everything as far as the pericranium. A crucial incision is then made over the selected spot, and the pericranium reflected sufficiently to allow a 1-inch trephine to be applied. On removing the disc of bone, a mass of blood-clot presents, which should be broken up with the finger and washed or scraped away. If the artery is seen bleeding on the dura

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mater, it may be possible to pick it up, and tie or twist it, or a fine curved needle threaded with catgut may be passed under it, and thus a ligature applied. If, however, the blood comes from a canal in the bone, the outer table must be clipped away sufficiently to enable the canal to be seen and plugged by a small piece of aseptic wax, sponge, or gauze, which may be left without danger. The flap is then replaced, and stitched down; drainage is not usually necessary, and should be avoided owing to the risk of infection.

The posterior branch of the artery can be reached by trephining immediately below the parietal eminence at the same level as for the anterior branch—*i.e.*, 1½ inches above Reid's base-line; or, again, it can be exposed nearer its origin at a spot 1¾ inches behind the external angular process of the frontal bone, and ¼ inch above the upper margin of the zygoma (Fig. 378, G).

3. **Wounds of the Internal Carotid Artery,** in its intracranial portion, are rare, but if complete are necessarily fatal. They usually result from penetrating wounds of the orbit, or from a gunshot wound, or the vessel may be torn by a splinter of bone in a fracture of the base of the skull. Mere fissures through the carotid canal do little harm, since there is plenty of room within it around the artery. Occasionally, however, the artery is slightly torn, and an aneurismal varix develops between it and the cavernous sinus. **Treatment.**—The injury is fatal in the majority of cases before help can be obtained; if not, compression of the carotid trunk or ligature of the internal carotid in the neck is the only hope. See also on orbital aneurism (p. 364).

4. **Intrameningeal Hæmorrhage** arises from wounds of the cerebral cortex or membranes in cases of fractured skull, or from concussion without fracture. The blood may be derived from the veins and capillaries so abundantly present in the pia mater, or from lesions of the inner wall of venous sinuses, or even from the middle meningeal artery, if the dura mater is also opened. It may be widely diffused over the surface of the hemispheres, or may be more localized. It is often but slowly absorbed, and may become encapsuled, constituting what is known as an *arachnoid cyst*—*i.e.*, a closed cavity containing serum, the walls of which are formed of fibrous tissue stained brown with hæmatin.

The **Symptoms** are those of concussion or compression, and need not be discussed further.

The **Treatment** is symptomatic, the patient being kept absolutely quiet, and all excitement and noise which might induce cerebral congestion excluded. If there be any focal symptoms, an exploration should be undertaken with a wide osteoplastic flap. The hæmatoma is evacuated after carefully opening the bulging dura; rarely is a bleeding vessel seen, but if one should be present it can be readily stopped by holding a small piece of muscle on it. No drainage should be employed. If there is no hæmatoma present, the base of the osteoplastic flap can be removed, allowing decompression to take place.

5. **Cerebral Hæmorrhage** occurs more frequently from idiopathic causes than from trauma, except in the case of severe lacerations. In the more aggravated forms, death is practically certain to result in a short time from coma.

Intracranial Inflammation.

Inflammation of the cranial contents is almost always bacterial in origin, and may follow a great variety of lesions, *e.g.*: (1) Injuries of all types, but especially compound or punctured fractures. (2) Middle-ear disease is perhaps the most frequent origin of these affections, the infection reaching the brain through an opening in the tegmen tympani, or spreading from the mastoid process along the sigmoid groove in which lies the lateral sinus. (3) It may extend inwards from scalp, face, nose, or neck by way of the emissary veins, or even along the sheaths of nerves. (4) It may accompany simple contusion of the cranial bones (p. 826) as a result of an auto-infective inflammation in these structures. (5) It may develop as a complication of pyæmia, septicæmia, pneumonia, scarlet fever, small-pox, and other general infective diseases. The causative bacteria in the preceding groups are generally staphylococci or streptococci, when the inflammation is due to traumatism; but the pneumococcus is usually present, when the mischief extends from the middle ear or accessory nasal sinuses. (6) It may constitute the chief manifestation of a general infective fever, spreading from the nasal fossæ, and known as *Cerebro-spinal Fever*. This affection is due to a specific organism, the *Diplococcus intracellularis* (Weichselbaum) or *Meningococcus*, and is extremely infectious. Certain individuals have been proved to be 'carriers' of this organism in their nasal fossæ, and infection may be spread by them by coughing and sneezing. Medical textbooks must be consulted for a description of this disease. (7) Chronic inflammatory trouble may arise from tubercle and syphilis.

It must be remembered that in actual practice the different forms of inflammation described below run into one another, and that the resulting symptoms are often a complex mixture of several types. For descriptive purposes the following groups may be differentiated:

(i.) **Subcranial Inflammation (Pachymeningitis)** manifests itself either as a simple thickening of the dura, or as an effusion of pus between the dura and the bone (subcranial abscess).

Simple Pachymeningitis results either from a slight simple depressed fracture, or from a contusion with or without a fissured fracture, or from the gradual spread of a mild infective inflammation from the overlying bone. The process is really protective in character, the dura becoming thickened. It may extend to the under surface of the dura, and lead to a localized lepto-meningitis characterized by adhesions between the cortex and the dura. If the process

extends no further, the clinical manifestations are slight, consisting merely of pain and localized headache. For treatment, see chronic meningitis (p. 868).

Subcranial (or **Extradural**) **Abscess** results from either a compound depressed or a punctured fracture, in which the dura mater is only separated from the bone and not lacerated, especially when the external wound is small and efficient drainage is not obtained. It also occurs by auto-infection in consequence of a simple contusion or fracture of the skull, leading to a detachment of the membranes and a collection of blood in the cavity thus produced. Any form of osteomyelitis of the cranial bones may determine its onset, as also the lodgment of a pyæmic embolus; but apart from injury, its most common cause is, without doubt, extension of inflammation from the middle ear.

FIG. 375 —SUBCRANIAL SUPPURATION, INVOLVING OVERLYING BONE AND CAUSING AN ŒDEMATOUS CONDITION OF THE SCALP—POTT'S PUFFY SWELLING (SEMI-DIAGRAMMATIC).

A perforation of the tegmen tympani (Fig. 377, B) allows of the invasion of the cranial cavity, and an abscess forms above the attic, which perhaps discharges through the ear; in other cases the suppuration extends along the groove for the lateral sinus. In the former instance, a localized subdural abscess may subsequently develop, limited by meningeal adhesions, and the intervening dura mater may slough; in the latter, thrombosis of the lateral sinus may follow.

The **Symptoms** produced are (1) those generally characteristic of suppuration, viz., a high temperature, with perhaps rigors. (2) The signs of intracranial pressure in the form of fixed headache followed by coma are also present, if the abscess is large, or if it affects the cerebral membranes sufficiently to cause a serous meningeal effusion. (3) If there is no open wound, an œdematous swelling of the scalp, known as *Pott's puffy tumour*, may develop over the site

of the abscess (Fig. 375). When there is a compound fracture of the skull, the margins of the wound look unhealthy, and at its base may be seen bare bone, yellow and dry, from which the pericranium has separated, perhaps with pus oozing out between the fragments. If the pus burrows towards the base of the skull, optic neuritis may develop. (4) Focal symptoms of spasm or paralysis may complicate the case if the dura over the motor area is involved. The **Treatment** of such a condition consists in evacuating the abscess cavity through a sufficient opening made by trephining, or by removing loose or diseased portions of bone, and providing for drainage. Sometimes more than one opening is required for this purpose.

When the affection follows otorrhœa, the mastoid antrum is usually opened up, as also the attic, and sufficient bone gouged or cut away from the roof to give effective drainage.

Occasionally the condition is of a diffuse subacute character, spreading widely over the surface of the dura mater and causing extensive mischief. In one case observed it followed a carbuncle on the back of the neck, and in another it was due to syphilitic disease of the cranial bones with septic complications. Pus spreads along the dura, the outer surface of which is thickened by granulation tissue, and the membrane itself becoming gradually softened allows the surface of the brain to become involved. The bones become carious with a certain amount of necrosis of the inner table. Pus finds its way to the surface through the bone, possibly through the foramina for emissary veins, and abscesses form beneath the scalp, which early becomes œdematous. The cerebral symptoms may be comparatively slight, headache and vomiting being the chief phenomena. The only treatment practicable is an extensive decompression, which lays bare the dura mater and removes the sequestra. In the cases mentioned above nearly half the cranium had to be removed in order to get clear of the trouble. The former case improved for a time, but died of acute mania; the latter case did very well, and fresh bone was formed over most of the denuded area.

(ii.) **Acute Diffuse Meningitis (lepto-meningitis)** is always infective in nature. The symptoms vary considerably in their intensity according to the site and method of inoculation and the activity of the organisms, but the whole pio-arachnal space is quickly involved. The superficial part of the brain is also invaded in the inflammation as well as the meninges, and the term 'meningo-encephalitis' would perhaps be the better appellation.

The **Symptoms** appear about forty-eight hours after an injury, although sometimes infection may be delayed beyond this period. In the early stages the patient complains of severe, constant, and increasing headache, associated with heat of head, a forcible pulsation of the carotids, a quick pulse, and general irritability of the brain, as indicated by vomiting, intolerance of light and sound, delirium, and perhaps convulsive twitchings of the muscles, not only of the head and back, but also of the extremities. The vomiting is of the

usual cerebral type—*i.e.*, it occurs without nausea, and has no relation to the ingestion of food. High fever is generally present, and possibly a rigor may occur at the onset. As the disease progresses, the patient gradually becomes comatose, the pulse is slow and full, the respirations are laboured, and death usually ensues in three or four days.

According to the site of infection, the inflammatory phenomena may manifest themselves more acutely over one part than another, and for descriptive purposes two chief varieties have been distinguished, viz., meningitis of the convexity and meningitis of the base. The general symptoms are alike in both forms, but when the convexity is involved, convulsions are a more prominent feature in the case, and may at first be limited to localized groups of muscles; in basal meningitis the temperature usually runs higher, the head and neck are more retracted, optic neuritis is more frequent, and some form of squint is not uncommonly observed.

On *post-mortem* examination the skull-cap is separated from the meninges with some difficulty; the dura mater is thick and congested, and the subjacent veins are manifestly distended; the cerebro-spinal fluid is increased in amount, and turbid from admixture with lymph or pus; the arachnoid is thick and opaque, the surface of the convolutions is flattened and œdematous, and lymph occupies all the sulci, matting them together; the cortical gray matter is usually red and congested; the underlying white substance of the centrum ovale is injected; the ventricles are distended with cerebro-spinal fluid, and the choroid plexuses are engorged with blood.

The **Treatment** consists in shaving the head and applying cold by means of an icebag, care being taken that the application is continuous, and not intermittent. In the robust general venesection is useful, but in weaker individuals purging and a low diet must be relied on. The patient should be kept absolutely quiet in a darkened room, and every source of irritation and excitement removed. Even if recovery ensues, it is often delayed, and for a while incomplete, especially as regards the mental powers, and precautions as to quiet and freedom from worry and strain must be maintained for a long time. An abundance of sleep in restful surroundings is essential.

If the condition is due to a localized infective lesion, this must, of course, be dealt with by suitable means—*e.g.*, the middle ear is opened up and diseased bone removed, depressed fractures are operated on, and localized drainage effected, etc. Apart from this, attempts have been frequently made to relieve the symptoms and determine a cure by means of operative measures, directed towards reducing the intracranial tension; the subarachnoid space has been opened below the tentorium, whilst others have employed cisternal or lumbar puncture, repeating it frequently (p. 844).. When one considers the intricate character of the space to be drained, the fact that it is sure to be subdivided into separate cavities by deposits of lymph, and especially when it is remembered that the brain sub-

stance is itself swollen, and that the important fourth ventricle has only a small communication with the subarachnoid space—all these considerations suggest that it is unlikely that much success will follow such treatment.

Acute Meningo-encephalitis is sometimes *limited* in character. It can only occur in the absence of tension, diffusion along the meninges being prevented by the formation of adhesions. It usually results from a localized inflammation of bone (Fig. 376), due to a contusion, a penetrating wound, or possibly to middle-ear mischief. The process ends in the formation of adhesions between the brain and its membranes, preceded or not by suppuration. Of course, where pus forms, a cure can only be established by operation.

(iii.) A **Subacute** form of meningitis is occasionally met with, coming on at a somewhat later date. The patient may have apparently recovered from his injury, with the exception of a fixed pain

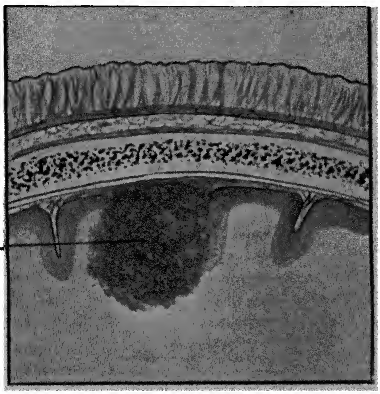

FIG 376—SUPERFICIAL ABSCESS OF BRAIN, SPREADING FROM SUBDURAL SPACE (SEMI-DIAGRAMMATIC)

in the head. The onset of the symptoms is often due to some indiscretion, and may be gradual or sudden. In all probability this affection is also microbic in origin, and the delay in its appearance depends either on the small number of bacteria present, or on their being in a low state of virulence; or possibly they have been latent for a time, and are aroused into activity by secondary causes; or, again, they may have worked their way gradually inwards along lymphatics or vessels from the periphery to the meninges. The symptoms are similar in character to those of acute meningitis, though somewhat less severe; but a fatal result is very apt to follow. In the *treatment* of this form, no active antiphlogistic measures should be adopted; since the patient's condition is somewhat asthenic. Absolute rest and quiet are essential; counter-irritation should be applied to the scalp and neck, and possibly mercury administered, or some absorbent organic salt of iodine. Lumbar puncture may be useful or a decompression may be desirable; if there be a local

lesion, the site of injury may be selected; but apart from this a subtemporal decompression can be undertaken (p. 856).

(iv.) **Chronic Lepto-meningitis** arises from very similar causes to the pachymeningitis already described (p. 863), but in addition may be associated with deep lesions, and may serve to limit the spread of infection; it is usually of a protective character. Syphilitic patients are perhaps more liable to its development than others. It is evidenced by infiltration and thickening of the membranes, which are usually adherent to one another and to the cerebral cortex. It gives rise to a localized headache, which is constant, and increased on excitement or the injudicious use of stimulants, whilst tenderness is often noted on deep pressure, and traumatic epilepsy may ensue. The *treatment* consists in attention to the general health, free action of the bowels, abstinence from excitement and stimulants, the local application of counter-irritants, and the administration of mercury. For the question of operating for traumatic epilepsy, see p. 881.

(v.) **Tuberculous Meningitis** is a condition usually seen in children, due to an invasion of the meninges with tubercle. The pial vessels are chiefly affected, and the base of the brain is mainly involved. Inflammatory adhesions follow, and the free circulation of the cerebro-spinal fluid is checked by the blocking of the foramina of Magendie and Luschka, so that the ventricles are often distended. For symptoms and clinical history, medical textbooks must be consulted.

Many attempts have been made to deal with this affection by surgical means, chiefly directed to the relief of tension by one of the methods of meningeal puncture (p. 844). One or two cases have recovered *post hoc*, but the prospects of success are poor.

(vi.) **Infective Thrombosis of the Sinuses,** though occasionally seen after injuries, is more commonly associated with suppurative diseases of the bone apart from trauma, and one variety, viz., that affecting the lateral sinus, is almost exclusively caused by disease of the middle ear. It is also induced by extension from scalp injuries as a complication of subaponeurotic cellulitis, or may spread inwards from erysipelatous or pyogenic lesions of the face, or suppurative conditions of the nose. Putting aside the results of chronic otorrhœa, the cavernous sinus is much more frequently involved than any other, and this affection is often secondary to suppuration in the sphenoidal or ethmoidal sinuses.

Pathologically, the same manifestations are observed as in any case of infective phlebitis. The sinus becomes impervious owing to thrombosis, which may develop slowly or suddenly; the clot becoming disintegrated gives rise to multiple emboli, whilst various inflammatory conditions of the surrounding tissues necessarily result—*e.g.*, necrosis or caries of bones; subcranial abscess; meningitis, simple and localized, or infective and diffuse; or even cerebral or cerebellar abscess.

The *symptoms* are mainly of a pyæmic nature. The temperature

is high, but with remissions, and often with repeated rigors; fixed headache and early and continuous vomiting are also marked features of the case. With these may be associated evidences of meningeal mischief, or of pulmonary trouble in the shape of dyspnœa, but sometimes diarrhœa and septicæmic manifestations may be the more prominent.

If the cavernous sinus is involved, marked exophthalmos, with congestion of the orbit, and even of the eyelids and face, may result, and ptosis or squint may also be set up by implication of the nerves which lie in the walls of the sinus.

During the late war many cases of thrombosis of the superior longitudinal sinus were observed, resulting from wounds by a bullet or shrapnel fragment. The symptoms included bilateral loss of power of the lower limbs, more marked distally; loss of cortical sensation; and such pyramidal symptoms as an extensor plantar response (Babinski), ankle clonus, etc. In addition there may be turgescence of the veins of the scalp and forehead, together with tenderness along the line of the sinus and epistaxis.

For local results and treatment of thrombosis of the lateral sinus, see p. 990.

Treatment, except for the lateral sinus, is but rarely possible, and hence the importance of preventing this disease by a most careful attention to asepsis in the surgery of the face and of the nasal cavity. For the lateral sinus much can be done, but for the other sinuses all that is feasible is attention to general measures.

Abscess of the Brain.

Causes.—Pyogenic infection is, of course, the ultimate cause of all cerebral suppuration, but the manner in which the organisms find their way to the brain varies considerably.

(i.) It may be due to *traumatism,* either in the early or late stages of head injuries. In the *early,* it is usually superficial, and connected with some infective lesion of the scalp, cranium or membranes, with or without a penetrating wound (Fig. 376). In the *later* stages the pus forms deeply in the white substance. It may be due to a penetrating wound, whether a foreign body is present or not, the microbes finding their way into the interior of the brain, either through the track of the missile, or along bloodvessels or their pio-arachnal sheaths. Sometimes it occurs apart from penetration, and then is due to auto-infection of a contused or lacerated area. Chronic abscess of this type is most frequently seen on the same side of the brain as the lesion, and the parietal and frontal lobes are most often affected; occasionally, however, it may occur on the opposite side in the same way as a contusion.

(ii.) It arises by extension of an infective lesion from without, the organisms reaching the brain by direct continuity of tissue, or by way of the bloodvessels. The commonest cause of all abscesses in the brain is *chronic otorrhœa* (Fig. 377), and the cerebellum is nearly

as frequently involved as the cerebrum. In the former the abscess is usually in the anterior portion of the lateral lobe (D), close to the back of the petrous bone, whilst in the latter the posterior portion of the temporo-sphenoidal lobe is most frequently affected (C). The inflammation may spread directly from the tympanic cavity or inner aspect of the mastoid process through the bone to the membranes, which become adherent to the brain, and then into the cerebral substance. Occasionally a subcranial abscess is first developed (Fig. 377), B), and the cerebral affection follows; sometimes a direct opening has been found through the tegmen tympani into an abscess cavity, and the abscess has even discharged itself and been drained in this direction. More commonly a layer of brain tissue intervenes between the membranes and the pus, and then infection must have been carried along the vessels and their sheaths.

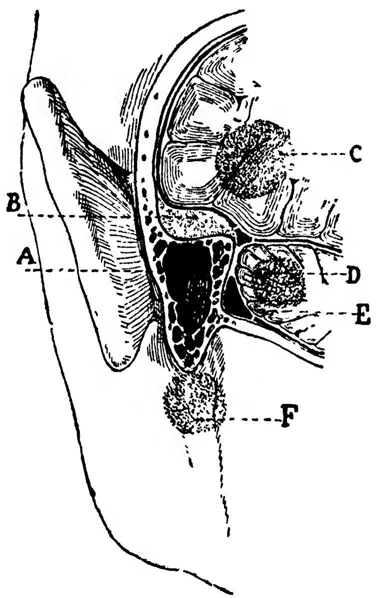

FIG. 377.—DIAGRAM TO REPRESENT THE COURSE OF INFLAMMATORY TROUBLE FROM SUPPURATIVE DISEASE OF THE MIDDLE EAR

A, Dilated and infected mastoid antrum; B, subcranial (extradural) abscess from infection through the roof of middle ear or mastoid; C, abscess in temporo-sphenoidal lobe; D, cerebellar abscess, E, lateral sinus; F, Bezold's abscess through perforation of tip of mastoid process.

Abscesses of a similar type occur in connection with suppuration in the frontal sinus, the abscess being usually acute and secondary to a frontal osteomyelitis, and occupying the anterior portion of the frontal lobe; it may also follow purulent infection of the sphenoidal and ethmoidal sinuses, or thrombosis of the cavernous sinus.

(iii.) The infective material may be brought to the brain by the blood in pyæmia, or after some of the exanthemata, such as scarlatina, typhoid, etc. Abscess of the occipital lobe is almost always of pyæmic origin. In suppurative conditions in the chest, pyæmic abscesses of the brain are not uncommon.

(iv.) A chronic abscess of tuberculous origin may also occur.

A cerebral abscess is usually single; occasionally more than one is present; *e.g.*, a cerebral and cerebellar may co-exist in connection with middle-ear mischief. The course taken by the case is generally chronic, and then the pus is encapsuled; in acute cases there is usually no limiting membrane.

The **Symptoms** vary somewhat with the method of onset and the characters of the abscess. If traumatic and due to infection from without, the case runs an acute course, associated with intense pain in the head, recurrent rigors, and rapid development of coma. Diffuse meningitis is often present, and the two conditions can scarcely be distinguished. In not a few of the cases of chronic abscess, all that the patient complains of is headache, until suddenly the temperature rises with a bound; he becomes unconscious and dies within a day or two. Such a course of events is probably due to the bursting of the abscess into the lateral ventricle or meningeal cavity, or to the onset of an acute spreading œdema.

When the symptoms are more characteristic, the late Sir W. Macewen described them in three well-marked stages. (i.) In the *Initiatory Stage*, which lasts from twelve hours to two or three days, the patient is suddenly seized with severe pain in the region of the ear, radiating perhaps throughout the head, and accompanied by a rigor of some severity. The temperature and pulse are both raised, and vomiting of a cerebral type is present; the tongue is foul, whilst anorexia and constipation are well marked. During this period the otorrhœa diminishes, or ceases entirely.

(ii.) In the *Fully-developed Stage* the patient lies quietly in bed in a dull, apathetic condition, able to answer questions but slowly, and with his brain evidently in a torpid state. The headache has to a great extent ceased, but tenderness over the temporo-mastoid region still remains. The temperature falls gradually and becomes sub-normal; the pulse is slow and full; and respiration is usually slow. The vomiting and constipation continue, and the patient's mouth and breath become very offensive. Loss of muscular power scarcely amounting to paralysis occurs in many cases where the motor track is involved, and the order in which this paresis appears is of localizing value. Thus, if a temporo-sphenoidal abscess is not far from the cortex, the face is first affected, then the arm, and finally the leg; but if the abscess is deeper and presses on the motor fibres in the internal capsule, the order in which these parts are involved is reversed Motor aphasia is sometimes well marked when the abscess is on the left side. If the abscess is placed posteriorly, it may press on the cerebellum through the tentorium, and cause symptoms of a cerebellar type. Optic neuritis (p. 877) is a somewhat unreliable sign, but if present is more marked on the affected side, whilst the corresponding pupil is dilated and fixed.

(iii.) The *Terminal Stage* is marked by a gradually increasing unconsciousness and death; or the abscess may burst into the lateral ventricle, causing sudden coma, a rapid rise of temperature and pulse, irregular respirations (often of a Cheyne-Stokes type), and death; or it may burst into the subarachnoid space, and then death is preceded by symptoms of diffuse lepto-meningitis.

The signs connected with a small **Cerebellar Abscess** (Fig. 377, D) are often very indefinite and vague, but as the abscess increases in size, the symptoms may become very characteristic. The patient

complains of giddiness, and staggers when attempting to walk, falling towards the opposite side. The head and neck are retracted; respiration is irregular and feeble; the pulse is often slow and weak; paralysis may be noted on one or both sides of the body, and may only affect the upper extremity; of course, vomiting, optic neuritis, and a low temperature are present.

Diagnosis.—From *meningitis*, a cerebral abscess is usually recognized by the fact that in the former condition irritative phenomena, such as acute and active delirium, contraction of the pupil, photophobia, rigidity and spasm of muscles, especially in the back of the neck, and severe pain, are more evident and are produced earlier. The temperature is usually high, and mental dulness comes on within three or four days of an injury, whereas an abscess rarely forms before the end of the first week. *Extradural abscess* (subcranial) is associated with a high temperature, earlier onset after an injury in traumatic cases, and more rapid compression symptoms; optic neuritis is unusual, and the vomiting is less troublesome. Localized œdema of the scalp may be present, or tenderness on deep pressure. In *thrombosis of the lateral sinus* the temperature is high and oscillating, optic neuritis may be absent, and there may be tenderness in the neck along the course of the internal jugular; in abscess symptoms of compression are associated with a low temperature and marked optic neuritis. It must not be forgotten that the two conditions may co-exist. It is often impossible to diagnose between a chronic abscess and a *tumour of the brain;* the symptoms in the latter usually come on more slowly than in the former, but the progress is steady and unrelenting; the temperature remains near the normal, and there is less gastric disturbance. The history of the case may throw some light upon its nature, since in cases of cerebral abscess there is generally some causative focus of infection. Tumour is more common in the frontal and parietal regions, abscess in the temporo-sphenoidal lobe. Optic neuritis is more marked and more common in tumour than in abscess.

Treatment necessarily follows the usual rule, viz., to give an exit to the pus as soon as possible; no delay is permissible when once the diagnosis is certain. The patient is prepared in the same way as for operation on a cerebral tumour (p. 877). A flap of scalp tissue is raised, and in such a manner as will serve most effectively for subsequent drainage purposes. The trephine is applied according to the rules given below, or in accordance with the special indications given by the symptoms of the case. When the circle of bone has been removed, the exposed surface and cut edge should be well rubbed over with powdered iodoform and boric acid or with Bipp, so as to guard them from infection. The dura mater, which bulges into the wound and does not pulsate, is then carefully incised. A mere slit often suffices, and this may open the abscess; but more usually the brain substance protrudes. It is carefully explored with a pair of sinus forceps, which is passed directly into it in various directions, or with a fine trocar and cannula. In a temporo-

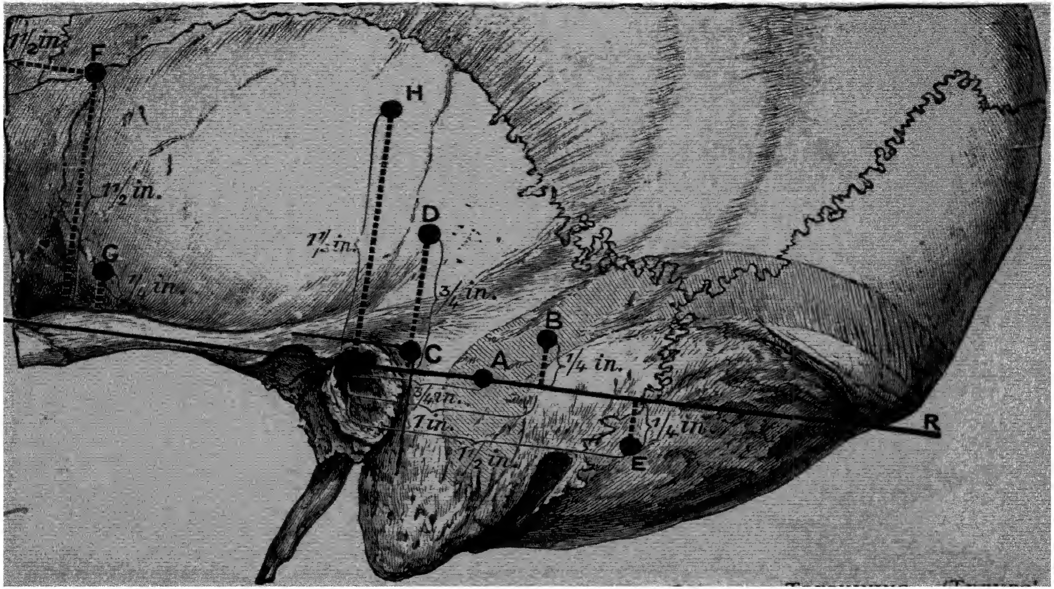

FIG. 378.—DIAGRAM OF ADULT SKULL (NATURAL SIZE) TO SHOW VARIOUS SPOTS FOR TREPHINING. (TREVES' 'SURGERY.')

The horizontal measurements are taken along Reid's base-line, R, R, which passes through the centre of the external auditory meatus; the vertical measurements are taken by drawing lines at right angles to the base-line. A, The sigmoid portion of the lateral sinus, a point ¾ inch along the base-line from the centre of the meatus; B, the transverse portion of the sinus, 1 inch behind the meatus, and ¼ inch above the base-line; C, the mastoid antrum, the point of meeting of two lines—one drawn along the upper wall of the meatus and parallel to the base-line, the other along the posterior wall of the meatus at right angles to Reid's line; D, for temporo-sphenoidal abscess, a line drawn ¾ inch upwards through the posterior border of the meatus at right angles to the base-line; E, for cerebellar abscess, 1½ inches behind the centre of the meatus, and ¼ inch below the base-line; F, for anterior branch of middle meningeal, 1½ inches behind external angular process of frontal bone, and 1½ inches above the zygoma; G, for posterior branch of middle meningeal, 1¾ inches behind external angular process, and ¼ inch above zygoma; H, for tapping lateral ventricle, 1½ inches above centre of external auditory meatus.

sphenoidal abscess the most likely direction to explore is downwards and inwards towards the tegmen tympani. Pus, when discovered, is allowed to escape by opening the blades of the sinus forceps. Sloughs are not uncommonly present in the cavity, and are removed by gentle irrigation with sterilized salt solution, or by being sucked up through a catheter. A drainage-tube is advisably inserted, and may be kept in position by stitching it to the margins of the incision in the dura, which is closed except for the passage of the tube. Sometimes it is wiser not to close the flaps around the tube, but to pack gauze round it, thereby determining the formation of adhesions, which will serve to shut off and guard from infection the meningeal cavity. The scalp flap is replaced in position, the tube being brought out through its centre, if need be. The tube is retained in position for two or three days, and is then removed. Symptoms of re-accumulation or of extension of the mischief to the meninges will, of course, necessitate a re-opening of the wound, and the institution of free and effective drainage. Occasionally a hernia cerebri develops as the result of opening a cerebral abscess.

For an abscess in the temporo-sphenoidal lobe, the centre-pin of the trephine may be placed 1¼ inches above Reid's base-line, and directly above the external auditory meatus; but a better situation is a spot ¾ inch above the posterior root of the zygoma, and directly above the posterior border of the osseous meatus (Macewen, Fig. 378, D). For an abscess in the cerebellum the point selected is 1½ inches behind the centre of the external auditory meatus and ¼ inch below the base-line (Fig. 378, E). In the latter case the soft parts, including the muscles and periosteum, should be stripped off the occipital bone, and turned downwards, and it is usually inadvisable to apply a trephine, as the bone is very thin, and may be broken through with a gouge. It is often necessary to carry through the cerebellar operation rapidly, as the respirations sometimes stop under an anæsthetic, though the heart continues to beat forcibly; as soon as the dura is opened, the respirations recommence.

In middle-ear disease diagnosis, both as to the presence of an abscess and its situation, is often doubtful. The antrum and attic are then opened and explored thoroughly, and according to whether the disease is more marked in the former or latter, the further steps of the operation are directed towards the cerebellum or cerebrum. By carefully removing bone behind and above the antrum, the lateral sinus is exposed; and by working above or below it, the cerebrum or cerebellum can be examined, and, if need be, incised. A similar result can be obtained by applying a ¾-inch trephine to a spot 1 inch behind the meatus and ½ inch above the base-line (H. P. Dean). The lateral sinus lies in the lower portion of the opening, and the dura over the temporo-sphenoidal lobe in the upper; by enlarging the opening downwards by Hoffman's rongeur, the cerebellum can also be explored.

Cerebral Tumours.

The chief **Varieties** of new growth met with in the brain are as follows: (i.) *Glioma*, which consists of a small round-celled neoplasm with a very delicate intercellular substance, similar in character to the neuroglia, occasionally undergoing cystic degeneration (p. 218); it may occur in any part of the brain. It is always continuous with the surrounding cerebral tissue, and is scarcely ever encapsuled, so that to the naked eye it may be indistinguishable from brain substance, although rather harder, and hence its limits can seldom be accurately defined or its removal completely effected. The cystic variety, however, is more likely to be encapsuled, and the prognosis is correspondingly better. (ii.) Secondary *sarcomata* and carcinomata also occur, and are as unfavourable as the gliomata in their characters. (iii.) *Endotheliomata* (meningioma) (Fig. 379) are not

FIG. 379.—ENDOTHELIOMA OF BRAIN.

uncommon tumours of the brain, growing usually from the membranes, and may attain considerable dimensions before causing symptoms. They press upon and excavate by pressure rather than infiltrate the brain. When situated in the anterior portion of the cranial vault, they are suitable for excision, although they may at times infiltrate and erode the overlying bone. In some cases they present the characteristic features of a psammoma (p. 243). (iv.) *Fibromata* develop in the cerebello-pontine angle, growing from the sheath of the auditory nerve, they are small in size and quite localized, but cause grave symptoms out of all proportion to their size. (v.) *Tuberculous foci* are met with in children either associated with or apart from any meningeal infiltration, varying in size considerably, and may be either firm and caseous, or with a diffluent centre, they may develop active signs after lengthy periods of quiescence. (vi.) *Gummata* of the brain usually spring from the

meninges, and are more irregular in shape than tuberculous masses. They are frequently multiple, and are seldom seen in children. (vii.) Occasionally *hydatid cysts* are found, as also other less common conditions. (viii.) *Pituitary* tumours are dealt with separately (p. 879). (ix.) Recently attention has been called to *blood tumours** of the brain, which occur in about 2 per cent. of cases. These are of two types—angiomatous malformations, frequently associated with nævi about the face, which are of either venous, capillary, or arterial formations, and may show the diagnostic sign of a bruit over the affected area; or true blood tumours, which Cushing has called hæmangioblastomas. These latter are always seen in connection with cysts, and it is only on examination of a portion of the wall that they can be recognized.

Cerebral tumours are more often observed in males than in females, and the different forms occur at varying periods of life. Thus, glioma and sarcoma are most common at puberty or in middle life; tuberculous foci, in children; gummata, in the fourth or fifth decade; carcinomata, in middle or late life; and parasitic tumours, in the second and third decades.

The **Symptoms** of a cerebral tumour in the early stages are comparatively seldom brought under the notice of the surgeon, but it is of the greatest importance that their significance should be recognized by the general practitioner, who ought, in case of doubt, at once to obtain the assistance of a skilled neurologist, as it is only through improved and earlier diagnosis that we may hope for better surgical results. It is quite possible for a tumour to attain considerable dimensions before causing serious symptoms; the brain can accommodate itself to increased pressure in an astonishing fashion so long as the circulation is not unduly disturbed. Supratentorial tumours usually conform to this requirement, and hence may already be of large size when the patient comes under observation, or before they cause serious pressure. Subtentorial tumours, on the other hand, are likely early to encroach on the fourth ventricle or aqueduct of Sylvius, thereby causing back-pressure within the lateral ventricles, and bringing about the grave terminal phenomena. When these have appeared, the time has usually passed for successful interference, except in a few cases of subtentorial origin.

The **early** symptoms consist in some localized modification of the cerebral function, probably combined with headache and perhaps vomiting. The character of the *localizing phenomena* varies, of course, with the part of the brain involved; thus, if the cortex of the motor area is affected, Jacksonian epilepsy is likely to result, in which a definite aura associated with a particular movement precedes the fit, which develops in an orderly fashion; in the later stages the fits are replaced by paralysis, and a localized monoplegia may be an important sign of a cerebral tumour. A subcortical lesion produces localized paralysis without convulsions. Motor

* Sargent and Greenfield, *British Journal of Surgery*, July, 1929; Cushing and Bailey, 'Bloodvessel Tumours of the Brain,' Baillière, Tindall and Cox, 1928.

aphasia would suggest an affection of Broca's lobe; word-deafness, an implication of the hinder end of the temporal lobe; and homonymous hemianopsia, a lesion of the occipital region. Interference with co-ordination, vertigo, and nystagmus point to mischief in the cerebellum, and the association of these phenomena with localized lesions of cranial nerves, especially of the seventh or eighth, points to the cerebello-pontine angle. The *headache* varies much in character, but is usually localized, occurs in paroxysmal attacks, and may be associated with local tenderness on deep pressure, if syphilitic in origin. It is increased by anything that causes passive congestion of the brain, such as coughing, and the sites of maximum pain and of the tumour often correspond. *Vomiting*, if present, is of the usual cerebral type—*i.e.*, it bears no relation to the ingestion of food, and is not preceded by nausea.

The **later** phenomena are purely those due to intracranial tension, which may aggravate or to some extent mask the localizing signs. Headache becomes more severe and persistent; vomiting and constipation are well marked; the patient becomes drowsy and apathetic, wasting rapidly, and the temperature is subnormal. *Optic neuritis* (choked disc or papillœdema) is generally present, and at first more marked on the side of the tumour. It is due to increased tension of cerebro-spinal fluid, which is thereby forced into the sheath of the optic nerve, and produces a condition of œdema, which extends to the lamina cribrosa and causes serious interference with the return of blood and lymph from the retina. There is in reality no inflammatory element about it. In the earlier stages the margins of the disc become blurred and indistinct, and the retinal veins congested and tortuous; the neighbouring retina is œdematous, and the vessels are only seen at intervals; linear ecchymoses may also occur. The vision may at first be but little affected; but if the case persists, atrophy of the disc and blindness follow, even in cases of gummata which have been cured by medicine, if that cure has not been attained quickly.

The **terminal** phenomena of a cerebral tumour are gradually increasing coma, and the supervention of symptoms similar to those of compression (p. 849), whilst the temperature may be subnormal or occasionally very high.

Treatment.—In every case, the possibility of the symptoms being due to gummatous disease must not be forgotten, and a test for the Wassermann reaction should always be undertaken; if positive, an intravenous injection of salvarsan may be given, or large and increasing doses of iodide of potassium (even up to 40 or 60 grains three or four times a day) should be administered, together with the inunction of mercury, before undertaking operative proceedings. Symptoms of gastric irritation must be prevented by giving some alkaline carbonate (especially the ammonium or soda salts), whilst the dose should be freely diluted with water.

Operation should be undertaken as early as possible, since even if no tumour is discovered the patient runs but little risk, whilst

delay may render it irremovable. For details larger textbooks must be consulted, but a few general points may be noted. Infiltration anæsthesia should be induced by the use of 1 per cent. novocaine and adrenalin, preceded by an injection of morphia ($\frac{1}{4}$ grain) and hyoscine ($\frac{1}{150}$ grain). If a general anæsthetic has to be employed, chloroform is preferable to ether. The skull is opened by turning down a large osteoplastic flap (p. 841), and with local anæsthesia the loss of blood is so much diminished that there is often no need to delay till a later date the subsequent steps. The dura is incised in such a way as to avoid as far as possible the chief meningeal vessels, and the brain exposed. It is gently explored by the finger or by a grooved needle, each stab being made exactly at right angles to the surface. It is but rarely that a cerebral tumour is so placed as to allow of its enucleation, not more than 10 per cent. falling within this category. If, however, a cortical neoplasm is found, it is isolated from the surrounding brain substance by blunt instruments—*e.g.*, the handle of a scalpel or a flexible knife made of platinum, as suggested by Horsley—and the mass freely removed. Hæmorrhage is controlled by the application of fine ligatures, or by pressure and the application of small pieces of muscle. Electro-surgical methods can also be used for the removal of the growth. The dura mater is then loosely stitched together and a drainage-tube inserted, reaching to the bottom of the wound, and brought out at one angle of the incision or through the centre of the flap. After the operation, the patient must be kept absolutely quiet, with the head slightly raised. The drainage-tube is removed in twenty-four or forty-eight hours, and the scalp wound is usually healed in six or seven days.

When the tumour is inaccessible or irremovable, or its situation doubtful, temporary benefit often results from *decompression*—an operation which consists in removing large areas of the cranium, and incising the dura mater, so as to allow a hernia cerebri to form. The decompression is best undertaken over the supposed site of the tumour, but has sometimes been subtentorial, with a view to influencing beneficially the vital centres. A considerable measure of benefit follows such operations, as evidenced by an improved mental condition, loss of pain, retrogression of the optic neuritis, and the preservation of sight. Of course, sooner or later the continued growth of the tumour results in the patient's death.

In dealing with cerebellar tumours, or those in the neighbourhood, either by removal or decompression, Cushing's cross-bow incision may be employed. It consists of a curved incision, with its concavity downwards, passing along the superior curved line of the occipital bone, and from its centre passes down a vertical incision as far as is necessary in order to reflect the muscles from the posterior aspect of the atlas. A considerable mortality is associated with this operation owing to the close proximity of the vital centres; rapid relief of tension produces serious shock, and it is well sometimes to delay the opening of the dura. Removal of

fibromata from the cerebello-pontine angle should be undertaken very slowly by *morcellement* for a similar reason.

Tumours of the Hypophysis Cerebri or Pituitary Body may affect the anterior or posterior portion, each of which produces a distinct hormone, with its peculiar effects in the economy.

The *anterior lobe* is derived from an outgrowth of the primitive pharynx, and its secretion is discharged into the blood-stream; an increase of this secretion produces gigantism if it occurs before the epiphyses have joined, and acromegaly if full growth has been reached. If there is hypopituitarism, sexual desire and potency are lost, and an early sign of the disease in females is amenorrhœa. Metabolism is also affected, showing a close connection with the thyroid gland; in hypopituitarism it is diminished, and in hyper-pituitarism it is increased.

The *posterior lobe* of the gland is a mixture of epithelial and nervous elements. There is some evidence that the secretion of this portion is discharged into the cerebro-spinal fluid, but its functions are by no means certain. Experimentally its removal leads to increased sugar tolerance, adiposity, and polyuria; its extract has a powerful effect on all plain muscle.

Pathologically, the pituitary body may be involved, either by tumours of the gland itself, adenomata, or by suprasellar tumours, which are usually endotheliomas or cysts of Rathke's pouch (adamantinomata). The clinical results consist either in an increase or loss of the pituitary secretion. Hyperpituitarism is always associated with the anterior lobe, and shows itself either as a gigantism in children, or acromegaly in adults, the former being a relative increase of all parts of the body, while in the latter the chief changes are in the skull, spine, and distal portions of the extremities. In hypopituitarism, the effects also differ as they occur in childhood or adult life. When developed in childhood, two types are noted: one in which the child is infantile in character, with small bones, and fine hairless skin (Lorain's disease); the other in which there is great and generalized deposition of subcutaneous fat, with sex infantilism and increased sugar tolerance, without any arrest in growth (Fröhlich's syndrome).

In all forms of pituitary enlargement signs of pressure may occur either early or late, and the surgeon is then anxious to know whether the tumour is in the pituitary itself, or is suprasellar in origin. If it is an adenoma of the pituitary, the sella turcica enlarges in size downwards and forwards, eventually depressing the sphenoidal air sinus; suprasellar tumours usually erode the clinoid processes, and there is flattening of the sella turcica. Varying disturbances of vision result from this, the most common being a bilateral hemi-anopia, followed in time by optic atrophy with complete blindness. Intracranial pressure is not markedly increased, but headache is complained of, usually without vomiting, and the sensation of the face may be impaired, together with modifications of taste and smell, and in the late stages there may be proptosis.

Operative Treatment is only indicated when pressure symptoms have arisen. Two chief routes may be employed, depending on the type of tumour. If the sella turcica is enlarged downwards to the sphenoidal air sinus, the transphenoidal route may be employed, as advocated by Cushing; but if a suprasellar tumour is present, it is best to approach it by an osteoplastic frontal flap, and by raising the frontal lobe an adequate exposure may be obtained, and the tumour evacuated or removed.

The Surgical Treatment of Epilepsy.

The only operative treatment for this condition now seriously considered is directed to the cerebral cortex, a proceeding dependent on the supposition that the epileptic convulsion results from an irritable condition of the cortex, which may be excited into convulsive activity by various stimuli, originating either in the brain or elsewhere. The late Sir Victor Horsley classified epilepsy as follows:

(1) Idiopathic (with no gross lesion).
  (*a*) Onset localized (focal).
  (*b*) Onset generalized.
(2) Jacksonian (always some gross lesion or traumatism).
  (*a*) Traumatic (with local or general convulsion).
  (*b*) Congenital.
  (*c*) Neoplastic (tumour, abscess, aneurism).
(3) Reflex (injury of spine, nerves, etc.).
(4) Hystero-epilepsy.

As regards the characteristic symptoms and pathological phenomena found in many of these conditions, students must refer to medical textbooks.

Before discussing the individual groups from the surgical standpoint, one or two general considerations must be noted. In the first place, the prognosis is gravely modified by the length of time that the epileptic habit has persisted, and if traumatic cases have lasted two years the outlook is very unsatisfactory. A careful study should also be made of the family history, as to the existence or not of a neurotic predisposition; in many cases of traumatic epilepsy this is well marked, and then the outlook is correspondingly bad.

It is now generally recognized that operation is useless in the **idiopathic** variety, even when the onset is accompanied by focal symptoms.

Congenital epilepsy is often more or less of the Jacksonian type, and usually depends on some injury sustained during birth. It is frequently associated with other evidences of cerebral mischief (spasm, paralysis, etc.) and with defective growth. If brought under observation early, and if the convulsions still remain localized, some good may follow operation; but if allowed to persist too long, the disease is irremediable by surgical means.

When due to **tumours, abscess,** etc., epilepsy is accompanied by other manifestations, which should guide the surgeon to a correct opinion as to the nature of the case and the operative outlook.

Reflex epilepsy is rare, and may perhaps be cured by dealing with the causative focus.

Traumatic Epilepsy is the term applied to an epileptic condition resulting from injuries. It may arise from any of the following conditions: (1) A neuralgic cicatrix in the scalp; (2) a slight unrelieved depression of the skull; (3) excessive formation of callus after a fissured fracture, or chronic thickening of the bone from osteitis after a contusion, whereby the dura mater is pressed upon and irritated; (4) chronic meningitis, usually associated with an adherent cicatrix in the brain, and particularly liable to occur in syphilitic patients; (5) a single depressed spicule of bone projecting into the cerebral substance; and (6) as a result of penetrating wounds of the brain which have been treated by decompression.

The **Symptoms** produced are epileptic seizures of the Jacksonian type, the exact manifestations varying with the portion of cerebral cortex which is involved. Localization of the lesion depends partly on the character of the aura, partly on the associated symptoms, such as a fixed headache or the presence of a cicatrix. The convulsions are localized to begin with, but often become general.

Operative Treatment is only applicable in those cases in which the convulsions remain localized; general convulsions place the patient in the category of idiopathic epileptics with a focal onset. The skull is opened over the site of the supposed injury, and it may be that some depressed fragment or spicule of bone is found; it will, of course, be removed. Occasionally a cyst may be found, due to the presence of a hæmatoma at the site of an old injury. If, however, nothing is found but an adherent cicatrix between the membranes and the underlying brain, it is still an open question as to whether the surgeon should proceed further. In a considerable number of cases the cicatrix and underlying brain substance have been removed; the fits ceased for a time, but in most instances recurrence followed sooner or later from the formation of a fresh adherent cicatrix. The locality of the lesion has a considerable influence, according to Horsley, on the result, since the prognosis is good in the motor area, middling in the sensory (parieto-occipital) region, and bad in the frontal. The obvious difficulty of dealing with epileptic conditions emphasizes the statements already made (p. 835) as to the importance of dealing with all depressed fractures of the skull, simple or compound, slight or severe, by immediate operation, so as to prevent, as far as possible, the development of the mischief. When there is a history of tubercle or syphilis, or of both, medicinal treatment should certainly precede operation.

Traumatic Insanity is sometimes produced by slight depressions or lesions, similar in nature to those causing epilepsy, and can occasionally be relieved by operation. Certainly, when a distinct history of injury precedes the mental aberration, and when there is any

localizing lesion or symptom, an exploratory operation is justifiable, and in a number of cases excellent results have followed. The type of insanity is not constant, but varies with the condition and environment of the individual.

Hernia Cerebri.

By hernia cerebri is meant a protrusion of the brain substance through an *acquired* opening in the skull. It thus differs from an encephalocele, which consists in the protrusion of brain substance through some *congenital* defect.

It is always an evidence of increased intracranial pressure, and may be looked upon as Nature's safety-valve for the relief of compression. It is met with in two distinct forms:

1. When a decompression operation has been performed for a cerebral tumour. The brain substance protrudes through the opening under the scalp, and by this means a temporary relief of intracranial tension is brought about, the patient's life prolonged, and possibly consciousness restored for a time. The tumour, however, continues growing, and sooner or later the patient dies comatose, unless the tumour is inflammatory and disappears.

2. The other variety, due to a compound depressed or punctured fracture, is the result of infection in the underlying brain substance, and the increased pressure within the skull thereby induced leads to a protrusion of inflamed and œdematous cerebral tissue through the wound in the dura, which is usually of small size. The tumour is soft and dusky in colour, and pulsates synchronously with the heart, the pulsations being often evident to the naked eye, and it usually increases in size somewhat rapidly. At first the mental condition of the patient is unimpaired, but sooner or later coma follows, if the hernia progresses, ending in the patient's death. To begin with, the mass consists mainly of œdematous granulation tissue covered by blood-clot, without much brain substance, but later on cerebral tissue itself may protrude. The condition is usually recovered from with care, but the patient has an adherent cicatrix, and is always liable to develop evidences of cerebral instability, epilepsy or insanity. In spite of this he may remain fairly well, if the original hernia did not involve the lateral ventricle; if this cavity or any of its prolongations was laid open and invaded by sepsis, inflammatory troubles are certain to supervene without much delay in spite of temporary healing. Within two years all such patients are likely to die of septic encephalitis.

Treatment.—Prevention of this affection must always be aimed at by endeavouring to render any wound involving the meninges aseptic and providing for relief of tension. Punctured wounds and depressed fractures of the skull, even when giving rise to no urgent symptoms, should always be operated upon, since freedom from tension may prevent the formation of a hernia cerebri, even should absolute asepsis not be attained. If, however, a hernia has developed,

treatment consists in the application of wet gauze packs soaked in hypertonic saline solution, or in glycerine and formalin(2 per cent),with the object of providing an escape for the fluid from the oedematous hernia; dry dressings are always undesirable. Gentle pressure is useful, and lumbar puncture is sometimes helpful. Under no circumstances should any attempt be made to slice away the mass. After a time, and sometimes quite suddenly, the condition begins to improve; the hernia diminishes in size, and the wound granulates over and heals, leaving, however, and adherent cicatrix.